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NAVAL SHIPS' TECHNICAL MANUAL

CHAPTER 225

STEAM MACHINERY CONTROL SYSTEMS

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CHAPTER 225

STEAM MACHINERY CONTROL SYSTEMS

SECTION 1

TYPES OF SYSTEMS

225-1.1 INTRODUCTION

225-1.1.1 Shipboard steam machinery control systems for all non-nuclear main propulsion steam generators are described in this chapter. The operating principles of these control systems and their interactions are also included. In some instances, information herein is given to provide engineering guidance to operating forces and industrial activities should a situation be encountered that is not specifically addressed within the technical manual for On-Line Verification (OLV) procedures; such as, piping arrangements and sensing line configuration.

225-1.1.2 Whenever guidance to aid personnel in making sound engineering judgments is included (as differentiated from mandatory requirements), it is identified as such to eliminate confusion and avoid misinterpretation.

225-1.1.3 Although this chapter is not intended to be used in place of a ship's Automatic Boiler Control (ABC) system technical manual, mandatory test requirements shall be met where applicable. Requests for deviation from the specific component calibration and piping requirements of either this chapter or the ABC system technical manual shall be made in writing to the Naval Surface Warfare Center, Carderock Division - Naval Ship Systems Engineering Station (NSWCCD-SSES) Code 925. In extreme situations, where deviations from flexibility test requirements and component calibration and piping arrangement are made, they shall be reported to NSWCCD-SSES (formerly NAVSSES). NSWCCD-SSES should be advised and assistance should be requested whenever unusual conditions arise which are not covered in this chapter or the ship's ABC system technical manual.

225-1.2 BACKGROUND

225-1.2.1 GENERAL. The Navy, in an attempt to modernize shipboard propulsion steam plants and increase overall plant efficiency, introduced 1,200 psi steam systems during the late 1950's. For various reasons, these 1,200 psi steam plants became a huge material, maintenance, and management problem that grew through the 60's and 70's. One of the propulsion plant equipment problem areas quickly identified was the ABC systems. There were so many variations in system design, as well as component design and function, that no two ships were alike and in many cases there were major system differences between firerooms on the same ship. The end result was a severely reduced control system reliability. In 1972, NAVSEA established the Steam Propulsion Plant Improvement Program (later renamed the Surface Ships Propulsion Systems Program) which later included 600 psi plants as well as 1,200 psi steam plants.

225-1.2.2 STANDARDIZED CONTROL SYSTEM CONFIGURATIONS. Under the Surface Ships Propulsion Systems Program, NAVSEA and NAVSSES developed standardized control system configurations to be installed by way of Ship Alteration on all high value ships (both 1,200 and 600 psi plants) of the Navy. This standardization also includes updating of the NAVSEA ABC system technical manual and use of an OLV manual to assist ship's force in calibration and trouble shooting of their systems. OLV procedures are included in volume II of ABC system technical manuals.

225-1.2.3 MAINTENANCE. To ensure proper ABC system operation through all boiler loads, the OLV manual provides definite static and dynamic checks with corresponding troubleshooting charts for each ship to assist personnel in identifying trouble areas and to make sound engineering judgments to correct any deficiencies.

225-1.2.3.1 The routine maintenance, calibration, and the OLV of the ABC systems are necessary for the reliability of the entire main propulsion plant. Improper ABC system maintenance and calibration result in unstable boiler and steam plant operation, usually characterized by:

a. Smoking conditions at all loads or intermittent (black or white) smoke

b. Excessive boiler steam drum water level excursion (usually beyond + 4 inches)

c. Excessive boiler setpoint steam pressure deviations

d. Instability of plant (cycling).

225-1.2.4 SYSTEM AND COMPONENT MANUFACTURERS. To eliminate confusion by the reader, this Naval Ships' Technical Manual (NSTM) chapter will refer to only two Navy standardized ABC system manufacturers. These main system manufacturers are commonly referred to as the following:

a. General Regulator, which is General Regulator Division of Tano, Inc.

b. Hagan, which is Combustion Control Division (Hagan) of Rosemount, Inc.

225-1.2.4.1 It shall be pointed out that although the two main manufacturers of ABC systems are identified as General Regulator and Hagan, this does not mean that all components within these standard systems are provided only by these manufacturers. Most standard control systems will have the controllers, relays, and automatic/manual control stations of the main manufacturer, with most final control elements by individual control manufacturers which are compatible with existing valves, governors, and so forth. Some examples of these individual component manufacturers are:

a. Moore Products Company

b. Leslie Company

c. I.T.T. Barton Corporation

d. Bailey Controls

e. Fisher Controls

f. Masoneilan of Worthington Controls Company

g. Woodward Governor.

SECTION 2

PRINCIPLES AND GENERAL REQUIREMENTS

225-2.1 INTRODUCTION

225-2.1.1 This chapter contains instructions and guidance for the proper maintenance of all non-nuclear main propulsion Automatic Boiler Control (ABC) systems.

225-2.2 AUTOMATIC BOILER CONTROL SYSTEMS

225-2.2.1 GENERAL. The ABC systems included herein are further broken into four distinct subsystems.

225-2.2.2 AUTOMATIC COMBUSTION CONTROL. The basic function of the Automatic Combustion Control (ACC) system is to measure and maintain within ±5 psi, the predetermined steam pressure setpoint value. The steam pressure setpoint value (at either the boiler steam drum, superheater outlet, or common superheater header) is maintained by manipulating the combustion air and fuel oil flow to the proper amounts to support the boiler load. This is to be accomplished under smokeless conditions as determined by the visual smoke periscope (one ACC system per boiler).

225-2.2.3 AUTOMATIC FEEDWATER CONTROL. The primary function of the automatic Feedwater Control (FWC) system is to maintain normal boiler water level setpoint within ±1 inch at all steady-state boiler loads. The FWC measures steam flow, feedwater flow, and boiler drum water level. The FWC utilizes this information to position the main feedwater regulating valve to maintain normal boiler drum water level. The three-element FWC system is designed to modify the setpoint during normal boiler operations to compensate for the effects of boiler water AM and swell (one system per boiler).

225-2.2.4 MAIN FEED PUMP CONTROL. The main Feed Pump Control (FPC) system maintains constant main feed pump discharge pressure and ensures that sufficient feedwater flow is available to support all boiler loads with minimal pressure deviations. The FPC measures the main feed pump discharge pressure at a common header point and positions each pump speed control valve to maintain desired header pressure setpoint.

225-2.2.5 MAIN FEED PUMP RECIRCULATION CONTROL. The Recirculation Control (RCC) system, currently installed on 1200 psig plants only, measures the flow of each main feed pump and positions the RCC valve (either open or closed) to maintain minimum flow through each pump at low end. The RCC system maintains sufficient flow through the feed pumps at low loading levels to ensure no pump damage will occur from overheating (one system per main feed pump).

225-2.3 PROPORTIONAL CONTROL AND LIMITATION-PROPORTIONAL OFFSET

225-2.3.1 GENERAL. To achieve an understanding of the more sophisticated combustion, feedwater, and FPC systems employed on naval ships, it is useful to first consider a simple system which will illustrate the various modes of control used. A tank is filled with water in accordance with Figure 225-2-1. Various loads can be imposed on the system by manipulating the valve on the tank outlet line. Suppose it is desired to maintain water level in the tank at a specified height (which shall be called normal). There are several methods to consider when determining what is needed to maintain a normal water level.

225-2.3.2 TYPICAL PNEUMATIC CONTROLLER. A cross-sectional view of a typical pneumatic controller used in naval combustion and FWC systems is shown in Figure 225-2-2. Forces are developed by pressures in the controller's four chambers. These forces then act on the ends of the controller beam. Examination of the valving arrangement in the output chamber (chamber number 1) leads to the following conclusions:

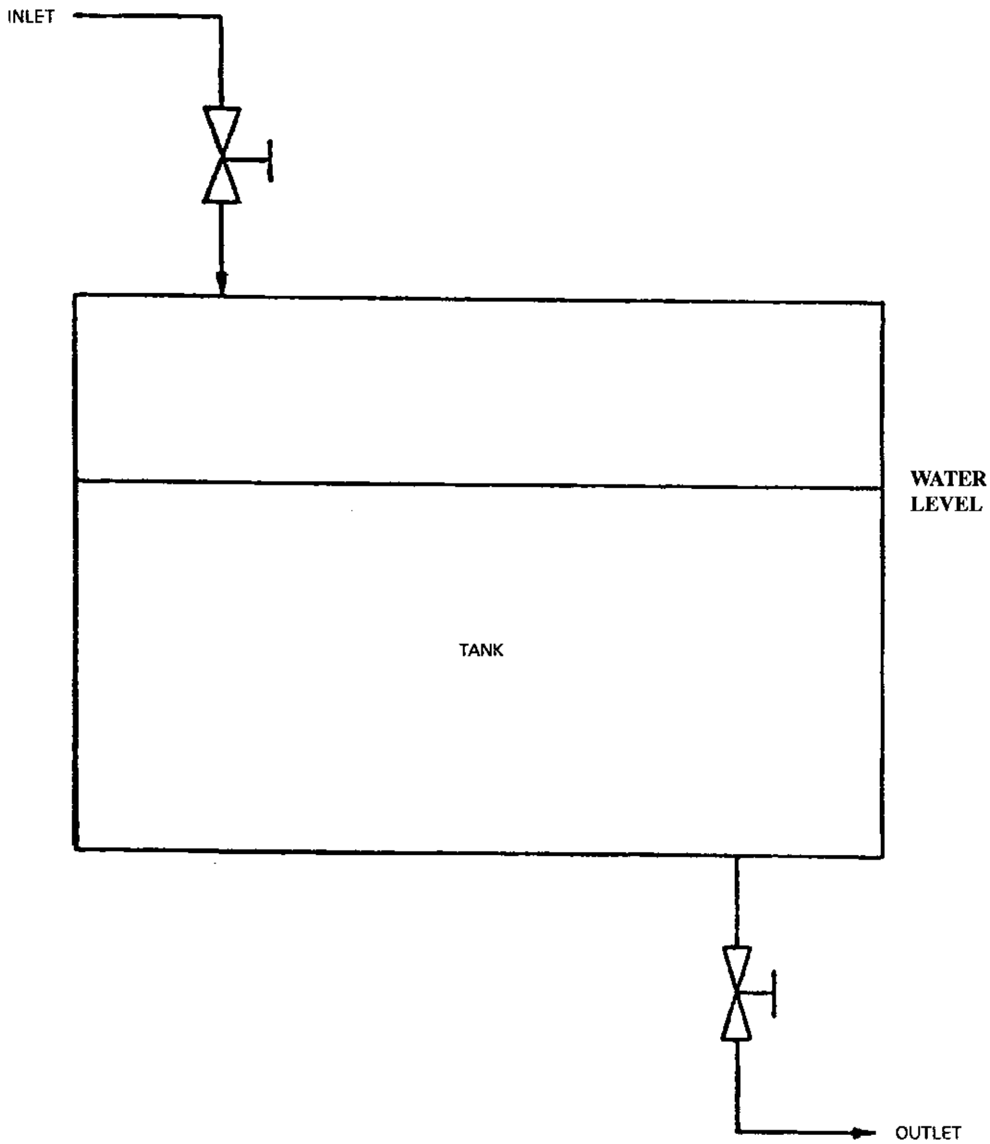
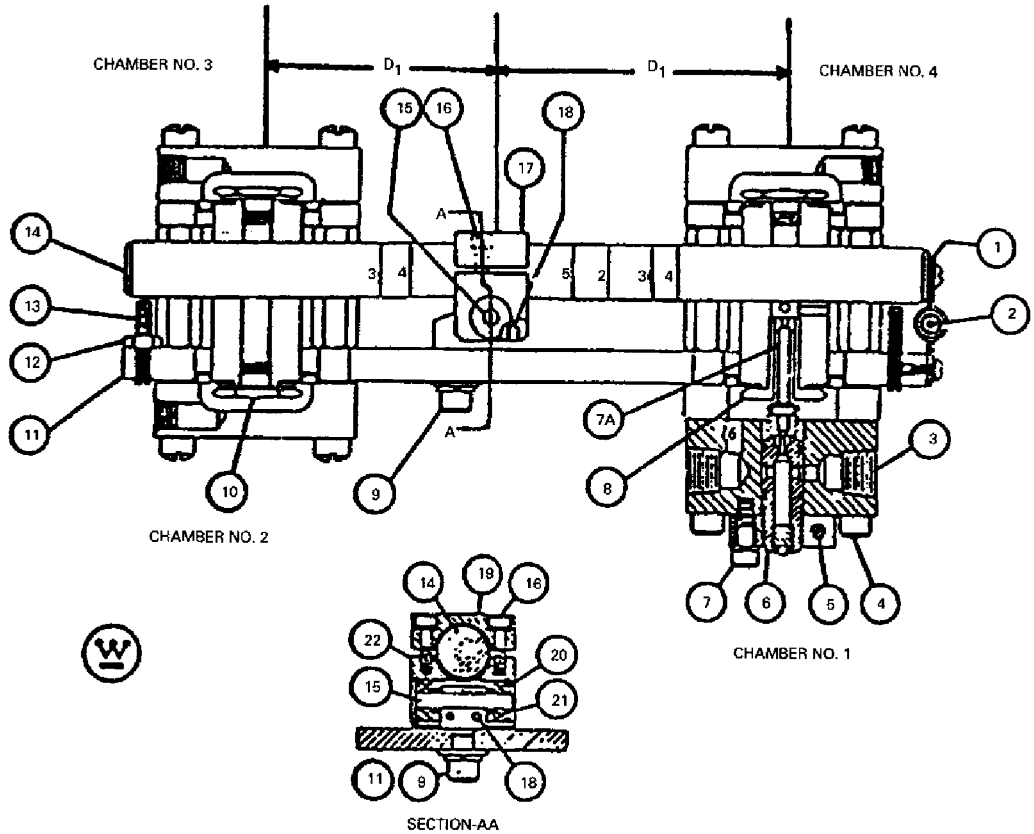


Figure 225-2-1 Tank with Inlet and Outlet Valves



1 CLAMP
2 STABILIZER CONNECTION
3 AIR SUPPLY CONNECTION
4 SCREWS
5 CLAMP SCREW
6 VALVE
7 SCREWS
7a VALVE STEM
8 EXHAUST SEAT ASSEMBLY
9 LOCKING SCREW
10 HEX HEAD NUT SCREW
11 BASE PLATE
12 LOCK NUT
13 STOP SCREW
14 BALANCE BEAM
15 FULCRUM SHAFT
16 LOCKING SCREW
17 FULCRUM ASSEMBLY
18 CLAMPING SCREWS
19 SUPPORT
20 SNAP RINGS
21 BALL BEARING UNITS
22 FULCRUM CARRIAGE

Figure 225-2-2 Typical Pneumatic Controller Cross-Section (Hagan Totalizer)

a. When the beam is perfectly horizontal the exhaust and inlet ports are closed. This is the only condition under which the output pressure remains constant.

b. If the right end of the beam is forced to move down, the exhaust port remains closed and the exhaust seat will push the valve stem down. The supply port will open and supply air will be admitted to the output chamber, increasing the output pressure. Increasing pressure in chambers 2 and 4 will increase output pressure.

c. If the right end of the beam is forced to move up, the supply valve will seat and the beam, with its exhaust port seat, will move away from the valve stem allowing air in the output to vent to atmosphere, reducing the output pressure. Increasing pressure in chamber 3 will decrease output pressure.

225-2.3.3 GAIN ADJUSTMENT. The leverage, which chambers 2 and 3 exert on the output chamber, may be adjusted by moving the fulcrum to the right or left. This adjusts the gain of the controller where gain is the amount of output change produced by a given input change to either chamber 2 or chamber 3. However, note that any change in output produced by a change in the input to chamber 4, is not affected by the gain or fulcrum setting, as it is on the same side of the fulcrum as the output chamber. Any change in input to chamber 4 is repeated 1:1 in the output chamber.

225-2.3.3.1 The controller beam is a simple lever against which forces developed by pressures in the various chambers act. If a pressure is introduced into chamber 2, the beam will not become level until the output pressure changes to a value such that the counterclockwise torque, developed by the output pressure, is equal to the clockwise torque developed by the pressure in chamber 2, or

$F_1 D_1 = F_2 D_2$

225-2.3.3.2 Since each diaphragm area is equal to 1 -square inch and since the force (F) produced on the beam by any chamber is equal to the pressure (P) in that chamber multiplied by the area of the diaphragm,

$P_1 D_1 = P_2 D_2$

where P_1 = pressure in chamber 1

P_2 = pressure in chamber 2

D_1 = distance from center of chamber 1 to fulcrum

D_2 = distance from center of chamber 2 to fulcrum therefore,

$$\frac{P_1}{P_2} = \frac{D_2}{D_1}$$

225-2.3.3.3 The gain (G) is defined as the ratio the output pressure to the input pressure, P1/P5, so by substitution it is seen that the gain of the device is

$$G = \frac{D_2}{D_1}$$

225-2.3.3.4 Knowing from physics that the sum of the torques around the beam's fulcrum shall sum to zero in order for it to be in equilibrium, we have (noting that clockwise torques are positive and counterclockwise torques are negative):

$P_2 D_2 + P_4 D_1 - P_1 D_1 - P_3 D_2 = 0$

$D_2 (P_2 - P_3) + D_1 (P_4 - P_1) = 0$

$D_2 (P_2 - P_3) = D_1 (P_1 - P_4)$

$$P_1 - P_4 = \frac{D_2}{D_1} (P_2 - P_3)$$

Output = $P_1 = G (P_2 - P_3) + P_4$

225-2.3.4 LOAD VARIATION AND COMPENSATION. Consider the process of Figure 225-2-1. This shows a water tank upon which various loads can be imposed in the form of water withdrawn from the tank by manipulation of an outlet valve. An inlet valve is used to allow water to be added to the tank. If sufficient water is supplied to the tank, the tank will not run out of water. In order that the water level in the tank be constant at any given level, the rate of waterflow into the tank shall be equal to the rate of waterflow out of the tank. If the flow rates were different, water level would be changing.

225-2.3.4.1 Waterflow through the inlet valve is directly proportional to the valve opening and the amount of valve opening is directly proportional to the pressure of the pneumatic signal applied to the valve operator.

225-2.3.4.2 Assume that with an input of zero pound-force per square inch gauge (psig) to the inlet valve operator, the valve is shut. As pressure applied to the valve operator increases, the valve begins to open. With 30 psig air input, the amount of valve opening delivers 50 pounds of water per hour. At 60 psig, the valve opening delivers 100 pounds of water. Also assume that the controller gain is 1:1, that is D1 = D2. Thus, the distance from the center of each chamber to the fulcrum of the beam is the same.

225-2.3.4.3 If the controller is to regulate the water level, it shall know what the actual water level is. A water level transmitter is installed which senses actual water level and develops a pneumatic output signal directly proportional to the water level. This is necessary since most pneumatic controllers will accept information only in the form of pneumatic signals.

225-2.3.4.4 If the calibration of the transmitter is such that at 5 inches of water, the water level transmitter output is 60 psig; at 3 inches of water, the water level transmitter output is 30 psig; at 1 inch of water, the water level transmitter output is 0 psig. The controller is depicted in Figure 225-2-3.

225-2.3.4.5 The following observations may be made:

a. If the outlet valve is shut, the water level will rise until the inlet valve is shut. This will occur when the pneumatic signal input to the inlet valve operator is 0 psig. This requires that the output of the controller be 0 psig (to shut the inlet valve so that flow in = 0 = flow out, such that level remains constant.) Applying the totalizer formula with P2 at a constant 60 psi signal and P4 set to 0 psi:

   P1 = G (P2 - P3) + P4

   Substituting values:

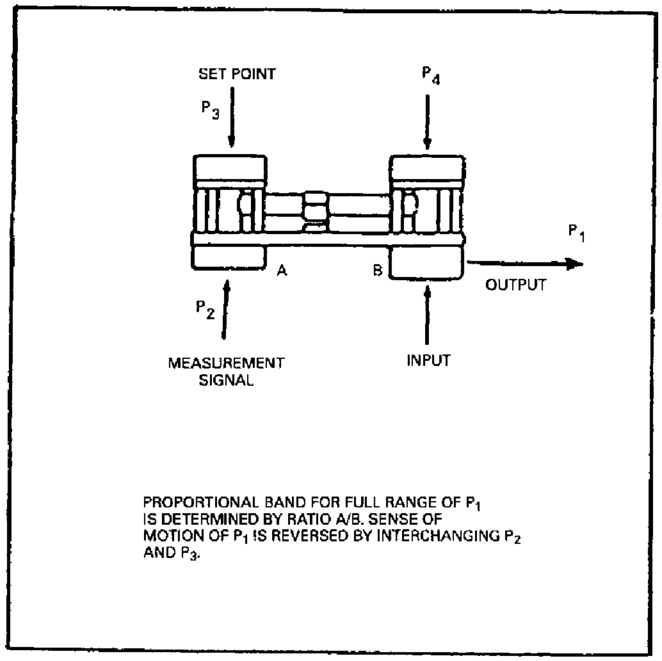
   0 = 1 (60 - P3) + 0

   or 0 = 60 - P3

   Solving for P3:

   P3 = 60 psi

b. Since P3 shall equal 60 psig in order that the inlet valve be shut, and since P3 is 60 psig only when the level is at 5 inches, the water level will stabilize at 5 inches when the outlet valve is shut.



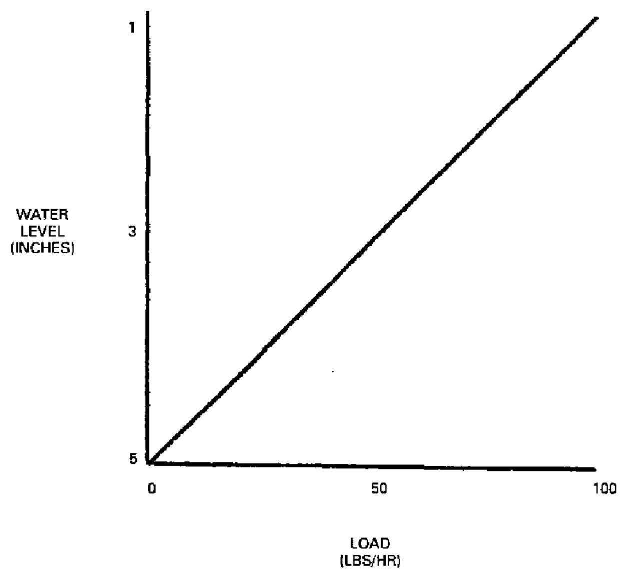


Figure 225-2-3 Controller with Proportional Band and Load Versus Water Level Graph

225-2.3.4.6 If the outlet valve is opened so that an outlet flow rate of 50 pounds of water per hour is established the consequences should be considered. Once again, water level should stabilize when the flow in rate equals the flow out rate (50 pounds per hour). When the flow in rate is equal to 50 pounds per hour, the pneumatic input signal to the inlet valve operator shall be 30 psig.

Substituting in the controller formula:

P1 = G(P2 - P3) + P4

Substituting values:

30 = 1(60 - P3) + 0

or 30 = 60 - P3

Solving for P3:

P3 = 30 psi

225-2.3.4.7 P_3 shall be equal to 30 psig in order for the flow rate into the tank to equal 50 pounds per hour and stabilize the level. Therefore, level will be 3 inches. If the outlet load is now increased to 100 pounds per hour, we need a flow of 100 pounds per hour into the tank to stabilize the water level. For this condition, pneumatic input to the inlet valve operator shall be 60 psig.

Substituting in the controller formula:

P1 = G(P2 - P3) + P4

Substituting values:

60 = 1(60 - P3) +0

or 60 = 60 - P3

Solving for P3:

P3 = 0 Psi

We see that with an outlet load of 100 pounds per hour water flow rate, the level will be 1 inch.

225-2.3.4.8 We find that we get a sloping straight line, when plotting water levels versus load (Figure 225-2-3). Since the line is straight, this shows that we have a linear proportional control system.

225-2.3.4.9 If it is necessary to hold water level constant at 3 inches, consider the variation shown in Figure 225-2-4 to the pneumatic controller used in Figure 225-2-3. The controller output is of course still fed into the feedwater (inlet) valve pneumatic operator. However, now it is also fed through a needle valve into a volume tank and into chamber 4. The effect of this arrangement allows the output signal from chamber 1 to bleed back into chamber 4. This causes the output signal to increase more than the initial change caused by an imbalance of pressures in chambers 1 and 2. Additionally, the constant input (P2) to chamber 2 of the controller is changed from 60 to 30 psig.

225-2.3.4.10 Under steady-state conditions, if water level is to be constant and steady, waterflow into the tank shall be constant and equal to waterflow out of the tank (load). If waterflow into the tank is to be constant, the valve position (opening) and therefore the value of the pneumatic input signal to the valve operator (controller output) shall be constant.

225-2.3.4.11 An examination of Figure 225-2-4 reveals that at steady-state pressure, P4 in the number 4 chamber of the controller will be equal to P1. (If it were not, air would have bled through the needle valve from the chamber having the higher pressure to the chamber at the lower pressure until equality existed.) Since P4 and P1 are equal and opposite, their effect is to cancel each other. (In other words they produce no net torque on the beam.)

225-2.3.4.12 The only way that P1 can be constant is if the totalizer beam is level; this requires that net torque on the beam be equal to zero. Since the net torque due to P4 and P1 is equal to zero, the net torque due to P2 and P3 shall also be equal to zero in order that the net torque from all four pressures be equal to zero. Therefore, since P2 and P3 act directly opposite each other they shall be equal.

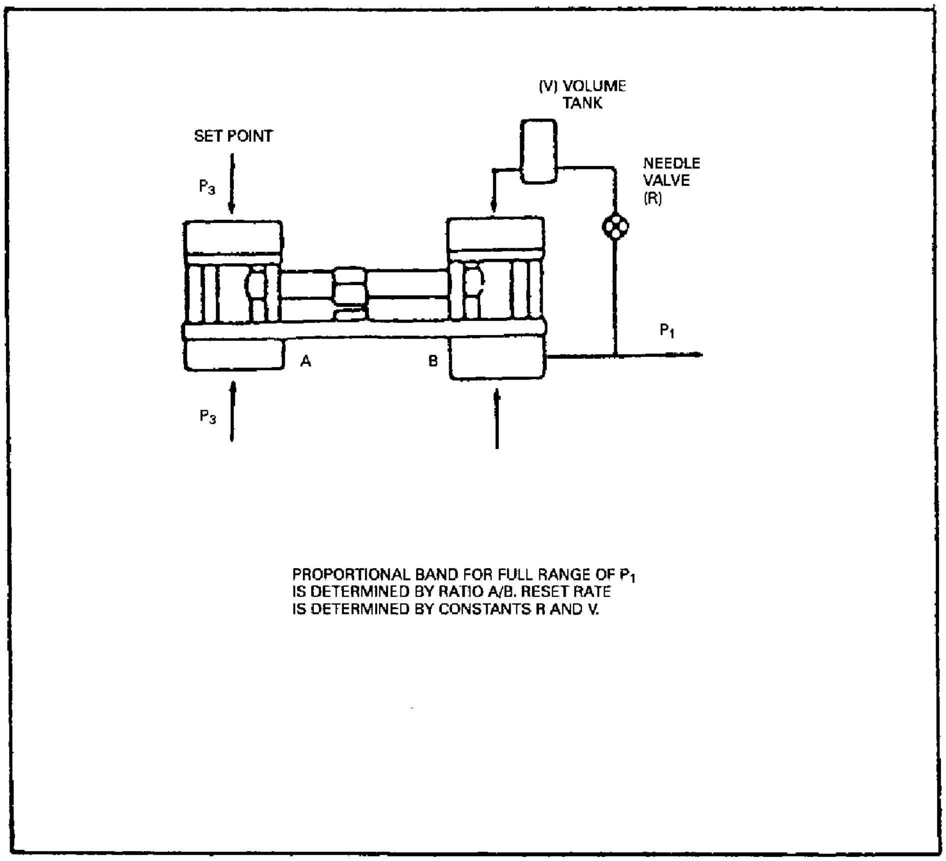


Figure 225-2-4 Controller with Proportional Band and Reset

225-2.3.4.13 This result may also be obtained by substituting P1 for P4 in the controller formula, since P4 shall equal P1 when stability exists:

P1 = G(P2 - P3) + P4

P1 = G(P2 - P3) + P1

or G (P2 - P3) + P1 - P1 = 0

G (P2 - P3) = 0

since the gain (G) is not equal to zero,

P2 - P3 shall equal zero

P2 - P3 = 0

or P2 = P3

225-2.3.4.14 Therefore, we see that a controller such as that shown in Figure 225-2-4 will not stabilize unless the water level signal (P3) from the water level transmitter is exactly equal to the setpoint signal (P2). Since the setpoint signal (P2) is 30 psig and the output of the water level transmitter is 30 psig, only when level is at 3 inches, the controller output can be steady only when water level is at the setpoint value of 3 inches. This is restated in a more conventional manner in the following paragraph.

225-2.3.4.15 Any controller of this type will maintain its output constant only when the controlled variable is steady and at setpoint. Whenever the controlled variable is not at setpoint, the controller will change its output in the proper direction and to the extent necessary to return the controlled variable to setpoint.

225-2.3.4.16 Additionally, it can be mathematically observed that the output of the feedwater flow controller now varies by an amount that is related to the difference between the setpoint and the tank level and the time that this difference or error exists. This is no longer simply a proportional controller. This is a proportional-plus-reset controller.

225-2.4 OPERATION OF TYPICAL GENERAL REGULATOR AND HAGAN COMBUSTION AND FEEDWATER CONTROL SYSTEMS

225-2.4.1 GENERAL. The following paragraphs explain the basic operating principles of a typical General Regulator or Hagan combustion control system. While most of the General Regulator and Hagan systems are designed on the same principles, certain variations and unique features do appear and are discussed later.

225-2.4.2 COMBUSTION CONTROL SYSTEM OBJECTION. The main objectives of combustion control systems (refer to Figure 225-2-5 and Figure 225-2-6) are to:

a. Regulate combustion air and fuel oil flow to that amount required to maintain steam pressure at the desired setpoint value for any steady-state steaming rate within the normal operating range of the boiler.

b. Regulate the ratio of combustion airflow to combustion fuel flow to that value which, during steady-state operation, provides the correct quantities of air and oil for optimum combustion.

c. Manipulate airflow and fuel flow to the boiler furnace as necessary to restore steam pressure to the setpoint whenever steam pressure deviates from that value.

d. Ensure proper fuel/air ratio during system load changes, thus preventing smoking under all conditions.

225-2.4.3 STEAM PRESSURE CONTROL LOOP. The primary function of the combustion control system is to maintain steam pressure at the desired (setpoint) value at steady steaming rates. The steam pressure transmitter develops a pneumatic output signal equal to the desired (setpoint) value when the steam pressure is at setpoint. The steam pressure transmitter output is the steam pressure controller input.

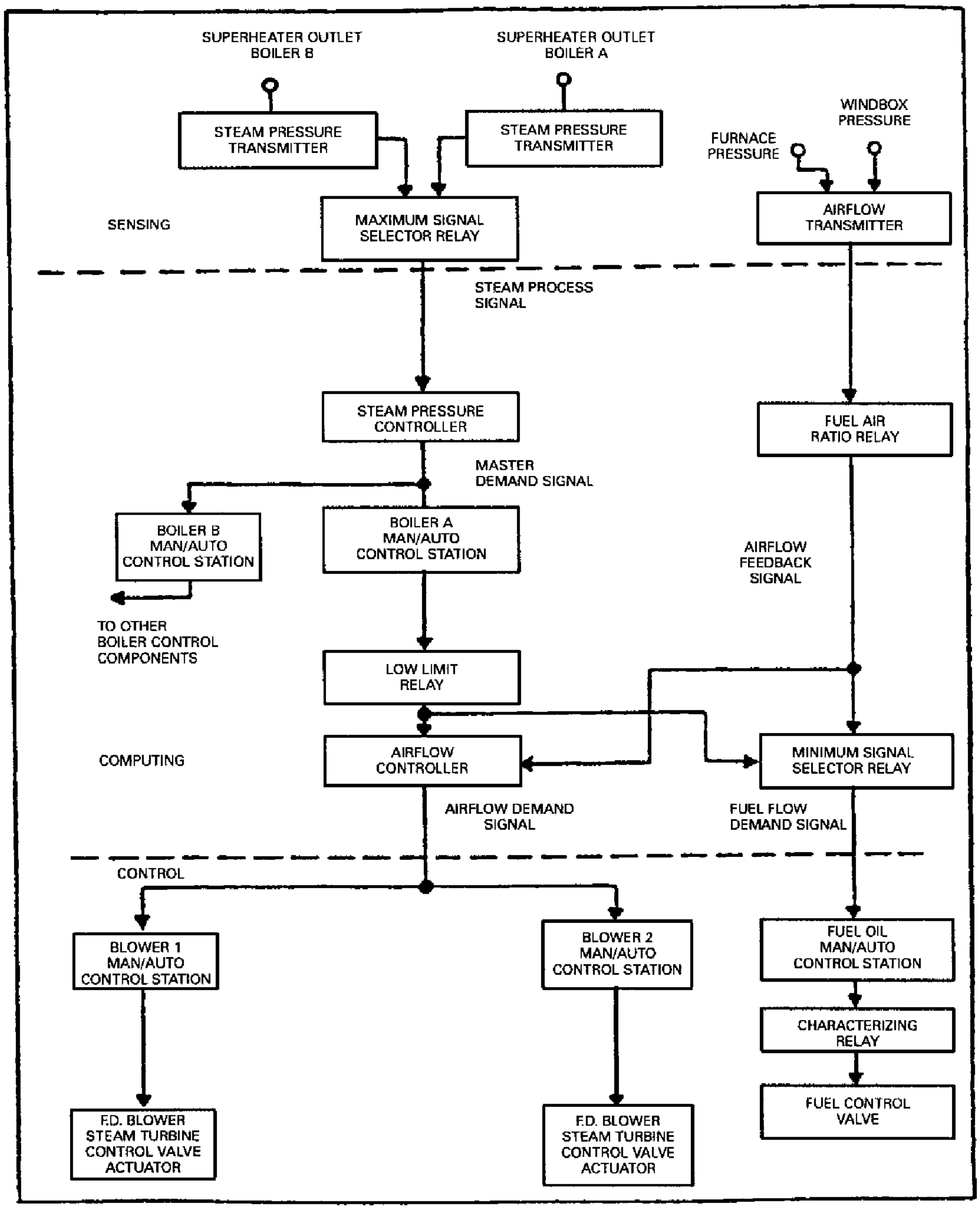


Figure 225-2-5 Block Diagram of Automatic Combustion Control System

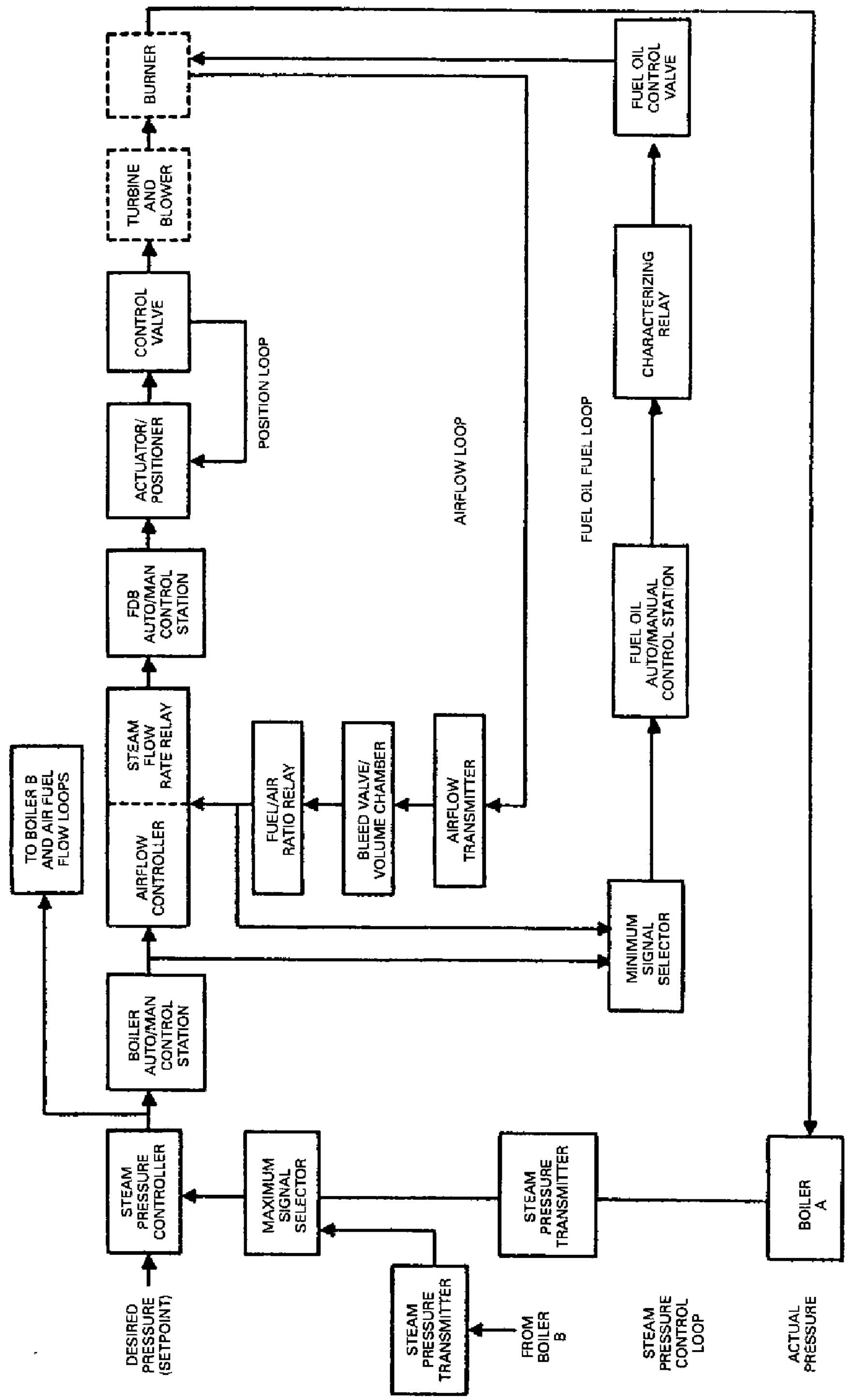


Figure 225-2-6 Control Loop Diagram for Automatic Combustion Control Steam Pressure Control Loop

225-2.4.3.1 The steam pressure controller develops whatever output is necessary to cause the remainder of the control system to regulate combustion air and fuel flow to the boilers to the amounts required to maintain steam pressure at setpoint whenever steaming rate is constant.

225-2.4.3.2 When total steam load is changed, a transient change in pressure occurs and the output of the steam pressure controller changes in the proper direction and by whatever amount needed to restore steam pressure to setpoint. When the control system and boiler have stabilized at the new load, the controller then maintains its output constant at that new value required to maintain steam pressure at setpoint at the new load.

225-2.4.3.3 The remainder of the control system is arranged and calibrated such that both airflow and fuel flow vary in a manner directly proportional to the output of the steam pressure controller, where the output of this controller represents a demand signal for both combustion air and fuel flow to the boiler furnace. This signal is called the waster demand signal and defined as a demand signal for both combustion airflow and fuel flow to the boiler furnace.

225-2.4.3.4 Controllers of this type are employed in virtually all pneumatic control systems which regulate the main boilers and associated machinery on naval ships. They are the brains of the control system.

225-2.4.4 PROPORTIONAL - PLUS RESET. Each proportional-plus-reset controller, employed in the control systems, has the following characteristics:

a. One input signal informs the controller of the value of the variable which it controls. This signal is generally referred to as the process signal or as the airflow feedback signal or steam pressure signal.
b. The other input signal informs the controller of the value which the variable it controls shall assume. This signal is referred to as the airflow demand signal or setpoint signal for the variable which the controller manipulates.

225-2.4.4.1 During steady-state operation, no difference between the process and demand signals to the controller exists. The controller output remains constant at that exact and unique value which maintains equality between those signals.

225-2.4.4.2 If any difference between the process and demand signals occurs, the controller changes its output in the proper direction and to the extent necessary to reduce that difference or error to zero. It achieves this result by opening or closing various control valves or causing actuators to move, which in turn, adjusts the necessary manipulated variables (airflow, fuel flow, and so forth) in response to the controller output.

225-2.4.4.3 Any adjustment of a controlled variable causes a corresponding change in the pneumatic output signal of the transmitter which monitors it. This signal is the process feedback signal to the controller, thus completing the circle, or closing the control loop.

225-2.4.4.4 When the difference between the demand signal and the process (controlled variable) signal vanishes and stability is attained, the output of the controller will remain constant at that value needed to maintain the controlled variable signal equal to its demand or setpoint signal.

225-2.4.5 BOILER CONTROL STATIONS. The output of the steam pressure controller is next routed to the boiler AUTOMATIC/MANUAL (A/M) control station(s). These devices, called boiler control stations, provide to the boiler operator the option of placing the boiler under the completely automatic mode of control or of regulating steam pressure by remote/manual means. Additionally, boiler control stations also provide the boiler operator with the option of parallel operation of boilers to divide boiler load equally among them while in automatic mode. When placed on AUTOMATIC, the boiler A/M control station passes or reproduces the master demand signal unchanged (or with bias) to the setpoint input port of the Airflow Controller (AFC) and to the minimum signal selector. When placed in the MANUAL position, the A/M control station blocks the AUTOMATIC signal and passes a manually set regulator signal to the AFC and to the minimum signal selector.

225-2.4.6 AIRFLOW CONTROL LOOP. The AFC is a proportional-plus-reset device. At the AFC, the master demand signal represents a demand for airflow per burner (see paragraph 225-2.4.12). To regulate airflow, the controller shall be informed of the actual value of airflow. Since the controller is a pneumatic device which can receive information only in the form of a pneumatic signal, one of its inputs shall be some measure of the actual value of airflow per burner. This information is furnished by the airflow feedback signal.

225-2.4.7 AIRFLOW FEEDBACK. The controller compares the airflow feedback signal to the master demand signal. If these signals are equal, its output remains constant at that value which maintains this equality. If any difference exists, the controller changes its output in the proper direction and to the extent necessary, to reduce the difference to zero. It shall of course, be understood that in order to change the feedback signal, the output of the controller shall regulate actual airflow by way of the forced-draft blower variable position inlet vanes and blower control devices.

225-2.4.7.1 The airflow feedback signal originates at the airflow transmitter which senses the pressure differential across the burner registers and produces a pneumatic output signal proportional to the square root of that differential. This signal is directly proportional to airflow per burner. The result is that airflow and the master demand signal have a straight line relationship.

225-2.4.8 FUEL/AIR RATIO CONTROL. The airflow signal passes to the fuel/air ratio relay from the airflow transmitter. This relay provides the operator with the means of modifying the airflow signal as necessary to provide the fuel/air ratio needed to ensure optimum combustion throughout the firing range of the boiler. A fuel/air ratio on-line check and adjustment procedure is incorporated into the ship's ACC system technical manual (see Section 4).

225-2.4.8.1 Control systems are designed to control airflow and fuel flow on a per burner basis. An explanation of this concept appears later. The output of the fuel/air ratio relay is called the airflow feedback signal. The effects of various ratio relay settings upon its input-output relationship are illustrated in Figure 225-2-7. Each straight line is labeled with the ratio setting it represents.

225-2.4.8.2 The calibration of the airflow transmitter is such that its output changes full range as airflow changes from minimum to that amount needed for optimum combustion when the highest capacity sprayer plates are in use and supplying maximum fuel flow. The overload sprayer plates and wide range spray plates (for example V.P. Mod. II) are designed so that their maximum capacity is approximately 120 percent of boiler load. Since the characterizing relay calibration is such that its output causes the fuel control valve to produce maximum fuel rate when its input signal is at the maximum value, it is evident that the ratio relay setting should be at or near 1:1 for General Regulator and 50 percent for Hagan when overload sprayer plates are in use. To achieve the maximum rate available with full power plates, the input to the characterizing relay shall also be at maximum. However, the airflow transmitter output shall be less than maximum because airflow requirements when using full power plates are lower. This will require adjustment to the fuel/air ratio relay such that it produces maximum output (characterizing relay input) with input (airflow transmitter output) associated with the required airflow for proper combustion.

225-2.4.8.3 A change in ratio relay setting from 1:1 changes the slope of the line which describes the input-output relationship; this in effect, adds to or subtracts from the airflow signal. The amount subtracted or added varies proportionally with airflow. Recalling the proportional-plus-reset nature of the AFC, increasing the airflow signal causes the controller output signal to decrease, thereby decreasing actual airflow for any given master demand signal. If the desired airflow and that produced with 1:1 setting are plotted versus fuel flow (and therefore, master demand signal) the following plot is obtained for full power sprayer plates (Figure 225-2-8).

225-2.4.8.4 If the ratio relay is set at a value greater than 1:1, the airflow versus fuel flow curve may be made to rotate until it coincides with the required curve. When some unfavorable condition results in poor combustion, it also provides a means of changing airflow to restore combustion to a state which is acceptable until corrective action may be taken.

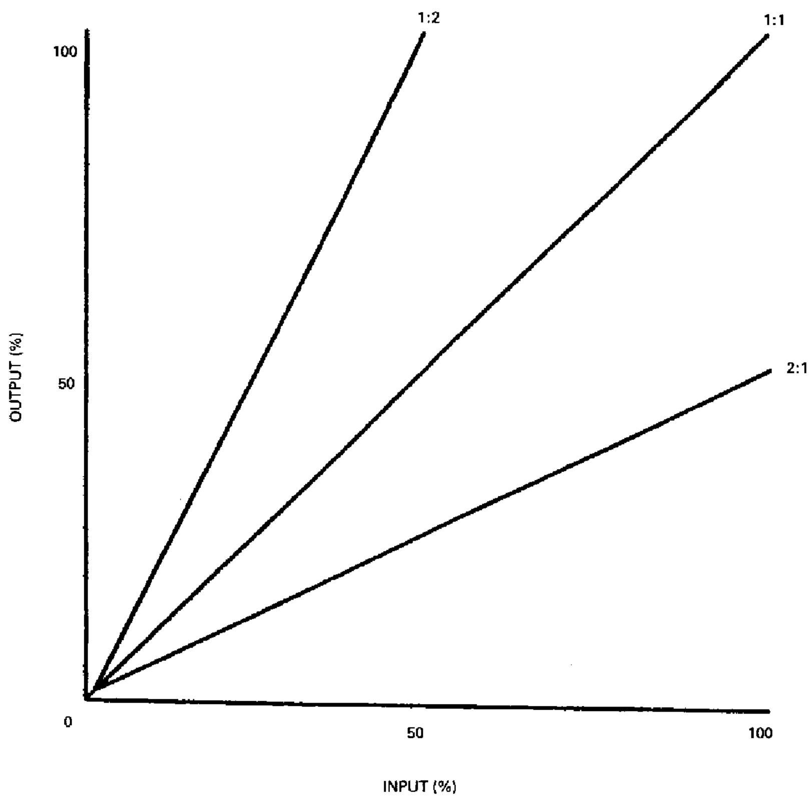


Figure 225-2-7 Ratio Relay Characteristics

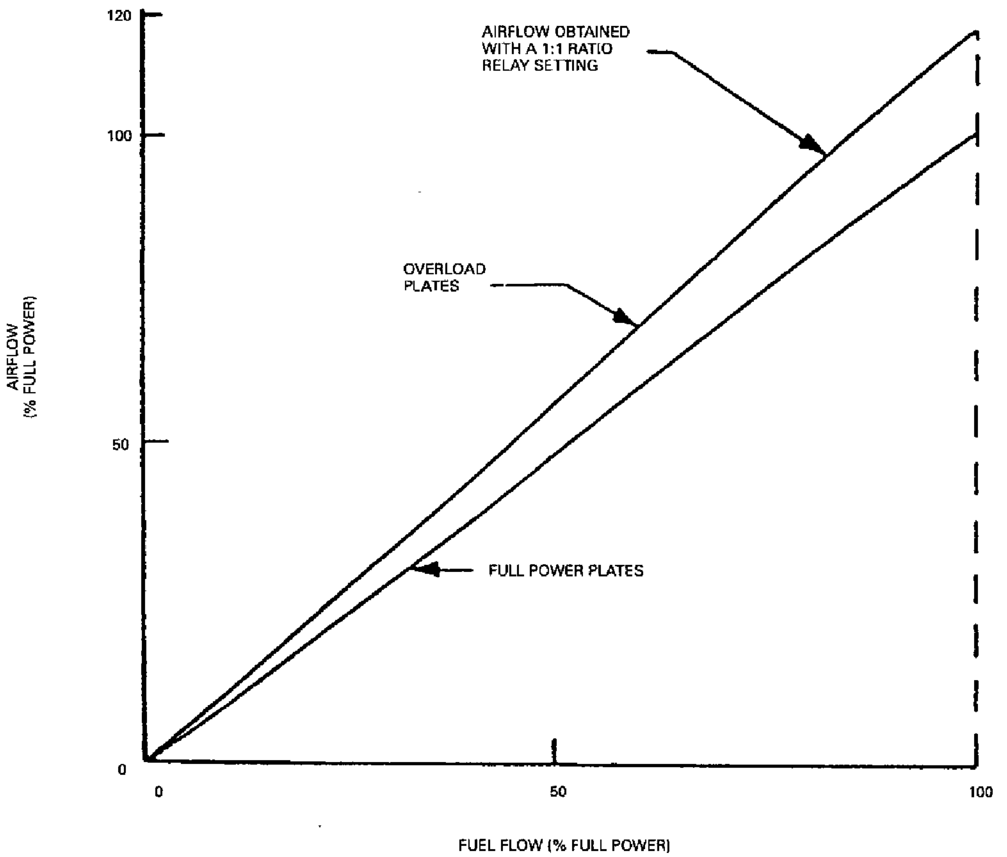


Figure 225-2-8 Airflow Versus Fuel Flow

225-2.4.9 STEAM FLOW CONTROL. On ships equipped with steam-driven forced draft blowers, the output of the AFC is transmitted to the steam flow rate relay which will duplicate the input signal and send out the same corresponding output signal.

225-2.4.9.1 The output of the steam flow rate relay is transmitted to the forced-draft blower A/M control stations. This provides the operator with the option of regulating forced-draft blower speed or in some cases variable position inlet vanes by REMOTE/MANUAL means or of placing the mode selector switch in the AUTOMATIC position, in which case the output of the AFC is passed through.

NOTE

Most systems have A/M control stations with a bias capability to provide a means for paralleling blower speed. The operator should not attempt to use this feature to readjust fuel/air ratio, as either the reset feature of the AFC will defeat the effort, or the signal will be biased to such an extent that the control system will be rendered inoperative.

225-2.4.9.2 The final control elements in the airflow loop are the forced-draft blower steam admission valves, Woodward governors, or variable position inlet vane control drives. These elements receive the signals from their A/M control stations and produce a definite steam inlet valve or vane position for each value of their input signals.

225-2.4.9.3 The steam valve positioners/actuators are calibrated in a manner such that they regulate forced- draft blower turbine steam flow as necessary to produce the required minimum forced-draft blower speed when positioner/actuator inputs are at minimum value and maximum required forced-draft blower speed when positioner/actuator inputs are at maximum.

225-2.4.9.4 The control devices shall also be calibrated such that blower speeds are within 300 rpm of each other over their operating ranges; at minimum they shall be set to produce equal blower speeds to avoid stall or surge per Naval Ships' Technical Manual (NSTM) Chapter 554, Forced-Draft Blowers. They shall also be set to prevent the steam valves from closing beyond the position required to provide the minimum allowable blower speeds should their input signals decrease below the normal operating range. Most valves have mechanical stops to limit this minimum stroke position. The valves stroke through full range as their pneumatic inputs change from a designed minimum to 100 percent.

225-2.4.9.5 The choice of this designed minimum is usually dictated by a careful consideration of various factors, such as excess air requirements at very low rates, elimination of excessive dead band, and maintenance of sufficient turbine lube oil pressure.

225-2.4.9.6 The variable position inlet vane drives, if provided, are stroked to pass the required minimum airflow when positioner/actuator input is at the lowest operating range value. They shall be set to prevent the vanes from closing beyond required minimum should their inputs decrease below the normal operating range. The variable position inlet vane drives stroke through their full range (minimum to wide open) as their pneumatic inputs change from minimum to 100 percent.

225-2.4.10 FUEL FLOW CONTROL LOOP. The first item in the fuel control loop is the minimum signal selector. The two inputs to this device are the master demand signal (steam pressure controller output) and airflow feedback signal (fuel/ air ratio relay output). On the CV-67 only, the feedback signal goes into a bias regulator prior to the signal selector. This device, normally set at 3.0 psid, improves steady-state stability. The signal selector transmits or passes an output equal to the lower of these two input signals should any difference exist. At steady-state no difference exists because of the proportional-plus-reset nature of the AFC.

225-2.4.10.1 The minimum signal selector output is at steady-state, equal to the master demand signal. As stated previously, the master demand signal is a demand signal for combustion air and fuel flow to the boiler furnace. The system is arranged such that steady-state combustion air and fuel flow are directly proportional to the master demand signal. The output of the minimum signal selector is a demand signal for fuel flow under all conditions, whether steady-state or transient. This signal is called the fuel flow demand signal.

225-2.4.10.2 The minimum signal selector ensures that proper fuel/air ratio exists during system load changes, thus preventing black smoke under all conditions. If boiler load is decreased, the master demand signal will decrease more rapidly than the airflow feedback signal. The selector win transmit the master demand signal as fuel demand and will therefore prevent excessive steam pressure increase.

225-2.4.10.3 The fuel flow demand signal now passes to the fuel oil A/M selector station which permits the operator to control fuel flow by REMOTE/ MANUAL when the mode selector is set to the MANUAL position. When the mode selector is placed on AUTOMATIC, the station will pass the oil demand signal directly through unaltered. The fuel flow control loop shall be designed to produce linear fuel flow versus fuel flow demand signal.

225-2.4.11 FUEL PRESSURE CONTROL. The fuel pressure control valve receives a pneumatic input signal and produces a fuel pressure directly proportional to it. With the exception of VP burners, the relationship between fuel flow through a sprayer plate and fuel pressure is not linear; that is, the change in fuel flow produced per unit change in fuel pressure is not constant over the range of operating fuel pressures. This nonlinear relationship between fuel flow and fuel pressure for a typical burner is shown in Figure 225-2-9.

225-2.4.11.1 The control valve is designed to operate over a pneumatic input signal range different than that of the fuel demand signal. It is apparent that an intermediate device is required to make each psi change in the fuel demand signal produce the same change in flow over the fuel oil control valve operating range and also to increase the range of the demand signal to satisfy the control valve input range. The desired effect of this intermediate unit on fuel rate versus fuel flow demand signal is represented by the straight line in Figure 225-2-9. The unit designed to produce this signal conversion is the characterizing relay.

225-2.4.11.2 The characterizing relay converts the input signal to an output signal, the relationship of which is opposite to that of the sprayer plate characteristic curve as shown in Figure 225-2-9. When placed between the fuel demand signal and the control valve, the characterizing relay takes fuel flow produced directly proportional to the fuel flow demand signal. The result is that the relation between fuel now and the fuel flow demand signal is a straight line. Since, at steady-state, the fuel flow demand signal is equal to the master demand signal, fuel flow is proportional to master demand. Since both airflow and fuel flow have a straight line relationship to the master demand signal, it follows that they may be properly matched over the operating range with comparative ease.

225-2.4.11.3 No two types of sprayer plates have precisely the same fuel flow versus fuel pressure characteristics; therefore, the characterizing relay calibration will be correct for only one type of sprayer plate. The calibration chosen will be that which is correct for the ship's normal underway sprayer plate. For ships equipped with both the full power and overload plates, the full power plate is regarded as the normal operating plate. When the overload plates are in use, the fuel/air ratio relay setting shall be reset to give adequate air for smokeless combustion. The fuel/air ratio will, in general, not be correct over the entire firing range for the overload plates.

225-2.4.11.4 The final component in the fuel oil control loop is the fuel pressure control valve. This valve receives a pneumatic pressure signal from the characterizing relay and maintains a discharge pressure corresponding to the given input.

225-2.4.12 AIRFLOW PER BURNER. Air and fuel flow are controlled on a per burner basis. Assume the following initial conditions for this discussion. The steaming rate is steady, one burner is in use, the boiler A/M control station is on MANUAL and set at mid-range, the fuel oil A/M control station is on AUTOMATIC, the airflow A/M control station is on AUTOMATIC, and the fuel/ air ratio relay is set to maintain optimum combustion. At steady-state, the airflow feedback signal is equal to the master demand signal and represents a specific pressure differential caused by the airflow through the burner register. The fixed master demand signal maintains a specific fuel pressure.

225-2.4.12.1 When a second burner is lit off, a momentary decrease in airflow differential occurs due to the increase in airflow area (air register). The airflow controller, however, increases airflow until the airflow feedback signal once again is equal to the master demand signal which is still at mid-range. In order for the airflow feedback signal to become equal to its original value, the airflow differential pressure across the registers shall again equal its original value. For draft loss across the two air registers to equal that which existed when only one air register was opened, the total airflow has to double. After the second burner is cut-in and equilibrium is achieved, the fuel oil pressure will be exactly that which existed with only one burner because the boiler A/M control station is in manual.

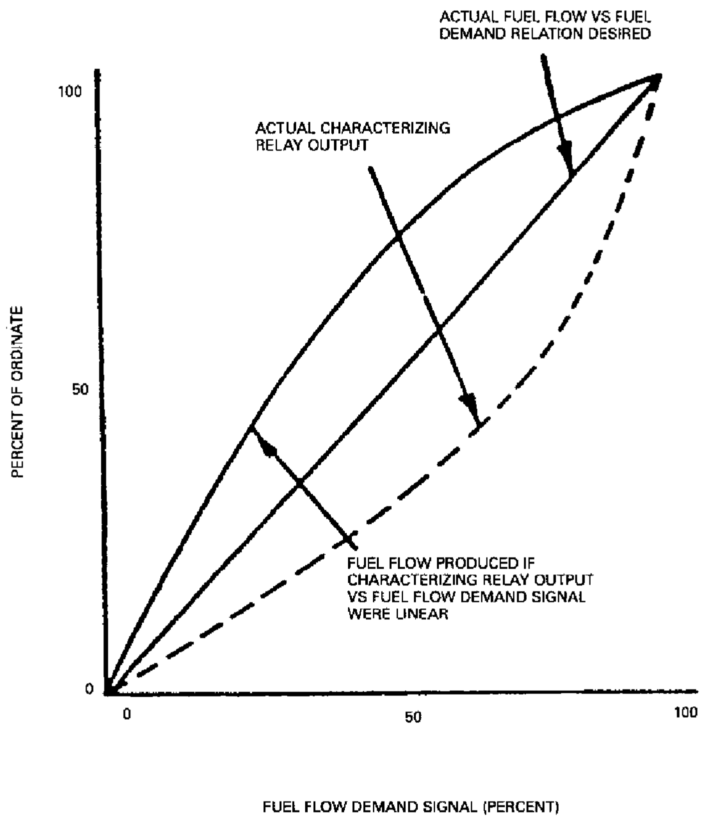


Figure 225-2-9 Fuel Flow Demand and Characterizing Relay Output

225-2.4.12.2 The fuel rate is now exactly twice that obtained when using one burner. Thus, by lighting-off the second burner and opening its register, twice the oil flow and the airflow have been obtained. From this, it is apparent that the master demand signal is a demand signal for airflow per burner and fuel flow per burner. This arrangement will also ensure that air and fuel will be supplied in the correct ratio no matter how many burners are in service.

NOTE

When steaming, in full automatic, cutting-in a second burner at steady-state will reduce fuel pressure such that fuel flow will remain constant.

225-2.4.13 OPERATION OF THE AUTOMATIC COMBUSTION CONTROL SYSTEM WHEN STEAMING RATE IS CONSTANT. Under steady-state conditions, the control system maintains the firing rate necessary to hold steam pressure constant at the setpoint value. The output of the steam pressure transmitter is constant and equal to the steam pressure controller setpoint; therefore, the output of the steam pressure controller is also constant.

225-2.4.13.1 The output of the steam pressure controller is the master demand signal. The master demand signal is a demand signal for both air and fuel flow per burner. Since this signal is steady, the output of the AFC will also be steady, for, at steady-state, the proportional-plus-reset action of the AFC matches the airflow feedback signal to the master demand signal. Blower speed or variable position inlet vane openings are held steady by the constant output of the AFC.

225-2.4.13.2 With the airflow feedback signal constant and equal to the master demand signal, the output of the minimum signal selector (fuel flow demand signal) is constant; hence, the output of the characterizing relay is constant. The fuel pressure control valve therefore maintains fuel pressure constant at the value necessary to maintain steam pressure at setpoint.

225-2.4.14 AUTOMATIC COMBUSTION CONTROL SYSTEM OPERATION WHEN STEAMING RATE IS INCREASED. When boiler steam load is increased, steam pressure decreases and the steam pressure transmitter signal decreases correspondingly. Simultaneously, steam flow is increased and the steam flow rate relay output signal will increase to the forced-draft blower, increasing blower speed. The steam pressure controller senses that the steam pressure signal is below setpoint and applying proportional-plus-reset action increases its output, calling for increased fuel and air to return steam pressure to setpoint. The AFC senses that the increased master demand signal is greater than the airflow feedback signal and applies proportional-plus-reset action, increasing airflow to reduce any difference between the airflow feedback signal and the master demand signal to zero. At the minimum signal selector, the master demand signal represents a demand for fuel oil flow. The forced-draft blowers, however, because of rotor inertia, are not capable of increasing airflow as rapidly as the fuel flow loop is capable of increasing fuel flow. The minimum signal selector therefore, selects the airflow feedback signal, and passes it to the fuel loop as the fuel flow demand signal. Because of this feature, fuel flow tracks but never exceeds airflow and the formation of black smoke is prevented. The boiler and control system then return to a steady-state condition at the new higher steaming rate.

225-2.4.15 AUTOMATIC COMBUSTION CONTROL SYSTEM OPERATION WHEN STEAMING RATE IS DECREASED. As boiler steam load is decreased, steam pressure increases causing a corresponding increase in the steam pressure transmitter signal. The steam pressure controller senses that pressure is above setpoint and applies proportional-plus-reset action to decrease controller output which reduces the flow of fuel and air to return steam pressure to setpoint. Simultaneously, steam flow is decreased and the steam flow rate relay will decrease output signal to forced-draft blowers.

225-2.4.15.1 The AFC senses that the decreasing master demand signal is less than the airflow feedback signal and takes proportional-plus-reset action, decreasing its output. The decrease in output reduces the airflow until the difference between the airflow feedback signal and the master demand signal converges to zero.

225-2.4.15.2 At the minimum signal selector, the master demand signal decreases more rapidly than the airflow feedback signal (because of blower inertia) and is selected as the fuel demand signal. Fuel flow tracks the master demand signal when steam load is decreased. This feature prevents an excessive steam pressure increase which might occur if fuel flow were forced to track the more slowly decreasing airflow. The boiler and control system then return to a steady-state condition at the new lower steaming rate.

225-2.4.16 UNIQUE FEATURES OF COMBUSTION CONTROL SYSTEMS. All combustion control systems in use on naval ships are of the inferential type. This type of system infers a certain fuel flow based on steam pressure signal or airflow feedback signal, depending upon which one is driving the system at that point in time. The Hagan combustion control system functions in almost exactly the same manner as the General Regulator combustion control system described previously with some minor difference in hardware.

225-2.4.17 BOILER FEEDWATER CONTROL. The most common design found aboard ships is a three-element type and is based upon metering of steam flow, feedwater flow, measurement of boiler water level, and applying this information to a control system whose output positions a main feedwater regulating valve.

225-2.4.17.1 Navy FWC systems are manufactured by the General Regulator Division of Tano, Inc. and the Hagan Control Division of Rosemount, Inc. (Figure 225-2-10 and Figure 225-2-11).

225-2.4.17.2 FWC systems are designed to maintain boiler water level at some condition defined as normal. This condition is usually represented by the center-line of the boiler steam drum. The desired value of boiler water level is referred to as the setpoint of the automatic FWC system.

225-2.4.17.3 Three-element FWC systems are designed to modify the demand signal, as required during normal operation, in order to compensate for the effects of boiler water and swell. Shrink and swell are phenomena that occur as a result of changes in mixture density when the steam load on the boilers is varied, as is the case during maneuvering operations.

225-2.4.17.4 When steam flow is increased, the primary effect is a momentary increase in steam drum water level, due to the expansion of water volume caused by the increase in boiler firing rate. This condition is referred to as swell. Due to the increase in steam flow, it is necessary to increase feedwater flow to match the demand for steam flow. However, it is necessary to compensate for the swell effect and thus, to delay the response of feedwater flow until such time as the increase in drum water level has settled out.

225-2.4.17.5 When decreasing steam load on the boiler, the reverse condition applies and a momentary decrease in steam drum water level occurs due to the contraction of water volume caused by a decrease in boiler firing rate. This condition is referred to as shrink. The usual arrangement, in which compensation for shrink and swell is provided, is one in which a change in steam flow creates a corresponding change in demand for feedwater flow. This demand is, however, modified by the influence of the signal representing boiler drum water level. For example, as steam flow increases although an additional demand for feedwater flow is generated because of the action of the three-element system, the signal representing boiler water level acts in the opposite direction and tends to suppress the response for feedwater flow.

225-2.4.17.6 The system is designed such that initially the magnitude of the change in water level corresponds to the magnitude of the change in demand. After the drum water level has reached its peak due to swell and water level begins to decrease, the influence of the increase in steam flow is felt and is transmitted through the control system as a demand for feedwater flow. These characteristics are basic to the operation of three-element FWC systems whether they be of the instrument type or of the direct mechanical variety.

225-2.4.17.7 In the instrument type FWC system, pneumatic signals representative of feedwater flow, steam flow, and steam drum water level are transmitted from pneumatic transmitters to the control system. The transmitters are usually a bellows actuated type. The steam flow signal is developed by the measurement of the pressure differential across a nozzle in the saturated steam line between the boiler steam drum outlet and the superheater inlet. Feedwater flow is measured in the same way by developing a pressure drop through an orifice in the main feedwater line to the economizer. In most systems, the flow transmitters are also provided with square-root extracting devices such that the pneumatic output signal pressures will be directly proportional to the metered flows. The signal representing boiler drum water level is usually established by applying a differential pressure head to a bellows type transmitter. The applied differential head is representative of the difference between a reference pressure leg, established by a reservoir connected to the high portion of the steam drum, and a variable pressure leg established by a connection to the lower portion of the steam drum, such that the change in height of boiler water levels affects the pressure on the low pressure side of the transmitter in reference to the reservoir level.

225-2.4.18 PROBLEM OBSERVATION AND CORRECTION. The following paragraphs discuss the observation and correction of various problems likely to occur with three-element FWC systems for boilers.

225-2.4.18.1 Steam flow and waterflow are metered and transmitted by pneumatic bellows-actuated transmitters. The outputs of these two transmitters are compared in a differential relay. When steam flow and waterflow are both equal, the output of the differential relay is at mid-scale, (30 psig in Hagan and 9 psig in General Regulator). The differential relay output may be thought of as a setpoint signal to the proportional-plus-reset FWC.

225-2.4.18.2 This setpoint signal is applied to the FWC, where it is compared with the feedback signal from the drum water level transmitter. Output from the drum level transmitter is called the long term demand signal. The feed flow transmitter signal is the feedback (response) signal to drum level. If a difference exists between the two inputs to the FWC, the controller applies a proportional-plus-reset correction which develops a pneumatic output signal pressure applied to the valve positioner input of the main feedwater control valve by way of the A/M control station located on the operating console. Typical difficulties experienced with systems of this type include transmitter calibration errors, differential relay calibration errors, controller calibration errors, and improper proportional band and reset rate settings of the relay and FWC. In most cases, the cause of difficulties can be determined by observation of system performance while the unit is steaming and reference to on-line verification troubleshooting charts.

225-2.4.19 MAIN FEED PUMP CONTROLS. Main FPC's shown in Figure 225-2-12 and Figure 225-2-13 include a system designed to maintain a constant pressure at the inlet of the main feedwater regulating valve and a system designed to provide recirculation capability to the main feed pump to protect the pump from overheating when operating at low flow rates. Systems of this type are furnished by the General Regulator Division of Tano, Inc. and the Hagan Combustion Control Division of Rosemount, Inc. FPC systems are relatively simple devices in comparison with boiler FWC systems and ACC systems.

225-2.4.20 HAGAN FEED PUMP CONTROL SYSTEM. In the typical Hagan FPC system (Figure 225-2-13), a proportional-plus-reset header pressure controller senses header pressure and compares it to a setpoint which consists of torques exerted on its beam by a spring. Should feedwater header pressure deviate from setpoint, this controller will apply proportional-plus-reset action to adjust steam flow to the feed pump turbines, as required, to reduce the deviation to zero.

225-2.4.21 GENERAL REGULATOR FEED PUMP CONTROL SYSTEM. In the typical General Regulator FPC system (Figure 225-2-12) a header pressure transmitter senses header pressure and transmits a linear output to the header pressure controller which compares this pneumatic signal to the setpoint chamber. Should feedwater header pressure deviate from setpoint, the transmitter will apply a proportional pneumatic output change to the controller which will apply proportional-plus-reset action to adjust steam flow to the feed pump turbines, as required, to reduce the deviation to zero.

LIST OF MATERIAL – QUANTITIES PER TYPICAL FIREROOM

	PC NO.	DESCRIPTION	QTY	MANUFACTURER	MODEL OR PART NO.	REMARKS
	1	STEAM PRESSURE TRANSMITTER OUTPUT 3–15 PSIG	2	MOORE PROD CO	1735–M44	INPUT 525–725 PSIG OR 1100–1400 PSIG
	2	MAXIMUM SIGNAL SELECTOR	1	GEN REG DIV	50683	
	3	STEAM PRESSURE CONTROLLER	1	GEN REG DIV	55	DWG NO. 10140
	4	HIGH LIMIT RELAY	3	GEN REG DIV	50991	
	5	LOW LIMIT RELAY	3	GEN REG DIV	50988	
	6	AUTOMATIC/MANUAL CONTROL STATION	6	GEN REG DIV	17502	WITH BIAS
A	7	STEAM FLOW/FEEDWATER FLOW DIFF RE & STM FLOW RATE RELAY	4	GEN REG DIV	50	DWG NO. 8–19406–01
B	8	AIRFLOW CONT & ROLLER FDW FLOW CONTROLLER	4	GEN REG DIV	50	DWG NO. 30516
	9	FORCED DRAFT BLOWER STEAM ADM VALVE POSITIONER	4	GEN REG DIV	PVP–N1–77	DIRECT ACTING, WITH GAUGES
	10	MINIMUM SIGNAL SELECTOR	2	GEN REG DIV	50684	
	11	FUEL–AIR RATIO RELAY	2	GEN REG DIV	1803	
	12	AIRFLOW TRANSMITTER	2	GEN REG DIV		W/(2) CAMILLANY ASSY INPUT 83072–01
	13	FUEL–AIR RATIO INDICATOR	2	MANNING MAX-WELL AND MOORE	PT NO. 5AAM72	
	14	AUTOMATIC/MANUAL CONTROL STATION	6	GEN REG DIV	30241	WITHOUT BIAS
	15	CHARACTERIZING RELAY, INPUT 3–15 PSIG	2	GEN REG DIV	1771–A	
	16	AIR FILTER	4	GEN REG DIV	30282	
	17	AIR PRESSURE REGULATOR	6	MOORE PROD CO	40N50	
	18	AIR SUPPLY RELIEF VALVE	1	FISHER CONTROLS	164A–1	
	19	FUEL OIL CONTROL VALVE	2	GEN REG DIV	32028	
C	20	NEEDLE VALVE	1	HAGAN	30244 – SEE NOTE 9	DWG NO. 539384
	21	AIR PRESSURE REGULATOR	2	MOORE PROD CO	40H100	
	22	NEEDLE VALVE/VOLUME CHAMBER	4	BAILEY METER CO	PT 5316733A1	
	23	SETPOINT ADJUSTER	2	MOORE PROD CO	41–15	
	24	FEEDWATER CONTROL VALVE POSITIONER	2	MOORE PROD CO	72G315R	
	25	PRESSURE GAUGE 3–1/2" DIA	4	ASHCROFT	1223UC	3–15 PSIG INPUT, 3–15 PSIG DIAL
	26	DRUM LEVEL TRANSMITTER, OUTPUT 3–15 PSIG	2	ITT BARTON	274A	
	27	STEAM FLOW TRANSMITTER, OUTPUT 3–15 PSIG	2	ITT BARTON	285/S907	
	28	FEEDWATER FLOW TRANSMITTER, OUTPUT 3–15 PSIG	2	ITT BARTON	285–S907	
	29	PRESSURE GAUGE, 2–1/2" DIA, 0–30 PSIG, 1/4" NPT, LM	41		NSN 1H–6685–00–246–2364	
	30	PRESSURE GAUGE, 2–1/2" DIA, 0–60 PSIG, 1/4" NPT, LM	5		NSN 1H–6685–00–246–2365	
C	31	AIR LOCK VALVE	9	FISHER	164A	FIELD MOUNTED
	32	FEEDWATER CONTROL VALVE, AIR TO CLOSE NO. 13 ACTUATOR W/2–13 TOP MOUNTED HANDWHEEL	2	MASONEILAN	37–10132	WITH EQUAL PERCENTAGE TRIM
C	33	AIR LOCK VENT VALVE	8	NONE	7165F48	
	34	AIR PRESSURE REGULATOR	1	MOORE PROD CO	41–100	
	35	AIR LOCK PANEL	1			NAVSEA DWG 4680421
	36	PRESSURE GAUGE, 2–1/2" DIA, 0–15 PSIG, 1/4" NPT, LM	10		NSN 1H–6685–00–246–2363	
	37	PRESSURE GAUGE, 2–1/2" DIA, 0–100 PSIG, 1/4" NPT, LM	1		NSN 1H–6685–00–244–1530	
A	38	VOLUME CHAMBER, 50 CU IN	2	HAGAN		DWG NO. 577720-001

NOTES:

1. THIS PLAN IS DEVELOPED TO SHOW STANDARDIZED GENERAL REGULATOR ACC/FWC SYSTEM CONFIGURATION.
2. THIS PLAN IS APPLICABLE TO THE SHIPS LISTED UNDER APPLICABLE SHIPS AND VARIATIONS (SHEET 2) AND PROVIDES SUPPLEMENTAL GUIDANCE FOR ACCOMPLISHING CLASS STANDARDIZATION SHIPALTS. THE DEGREE OF STANDARDIZATION IS LIMITED IN SCOPE. FOLLOWING ACCOMPLISHMENT OF APPLICABLE SHIPALTS, THE VARIATIONS FROM THE STANDARD SYSTEM LISTED UNDER APPLICABLE SHIPS AND VARIATIONS WILL REMAIN.
3. ALL QUANTITIES SHOWN IN LIST OF MATERIAL ARE FOR A TYPICAL FIREROOM AS DEPICTED ON SHEETS 3 THRU 5. THESE QUANTITIES WILL VARY ACCORDING TO REQUIREMENTS LISTED FOR THE STANDARD SYSTEM VARIATIONS. QUANTITY CHANGES FOR PC NOS. 17, 29, 30, 31 AND 33 SHALL ALSO BE MADE AS REQUIRED BY THE SYSTEM VARIATIONS.
4. (B) ALL VARIATIONS PRECEDED BY * ARE DEPICTED ON SHEETS 6 THRU 11.
5. SOME OF THE SHIPS LISTED IN THE TABLE OF VARIATIONS ASSUME ACCOMPLISHMENT OF THE BAILEY SYSTEM REPLACEMENT SHIPALT.
6. ALL SENSING PIPING TO BE INSTALLED ACCORDING TO NAVSECPHILA DRAWING NO. 4182, REVISION H, STEAM GENERATING PLANT (NON–NUCLEAR) AUTOMATIC CONTROL TRANSMITTER SENSING PIPING.
7. (B) CUTOUT VALVES ASSOCIATED WITH PC NO. 25 ARE NOT ESSENTIAL. THESE VALVES, IF ALREADY INSTALLED IN EXISTING SYSTEM, MAY BE RETAINED.
8. SOME SHIPS HAVE DUPLEX GAUGE SIMILAR TO PC NO. 13 FOR STEAM/FEED FLOW INDICATOR.
9. (C) SOME SHIPS HAVE G.R. MODEL 80480 AIRFLOW TRANSMITTERS IN PLACE OF MODEL 30244 (PC NO. 12).

Figure 225-2-10 General Regulator Automatic Combustion Control and Feedwater Control Systems (Sheet 1 of 11)

APPLICABLE SHIPS AND VARIATIONS		APPLICABLE SHIPS AND VARIATIONS	
SHIP GROUP	VARIATIONS	SHIP GROUP	VARIATIONS
AD 37, 38	9, 10	A AFS 1, 2	1, 15
AE 26, 27, 28, 29	1, 3, 5, 7, 10	AFS 3	1, 4, 15
AE 32, 33, 34, 35	D 1, 3, 7, 10, 19	B AO 177, 178, 179, 180, 185	10, 11, 12, 17
AOE 1	1, 11	B LPH 2, 3, 7, 9, 11	10
AOE 2, 3, 4	1, 7, 10, 11	B LPH 10	4, 10
D AOR 1, 2, 3, 4, 5, 6, 7	1, 4, 7, 10, 13	B LPD 4, 5, 6	9, 10
AS 33, 34	9, 10	B LHA 1, 2, 3, 4, 5	2, 10, 16, 18
AS 36, 37	9, 10	B CV 63	1, 6, 10, 11
CV 62	1, 6	C AS 39, 40, 41	4, 10
CV 64	1, 5, 6, 10, 11	C CV 63	1, 5, 6, 11
LCC 19, 20	5, 7, 10, 11, 12	D AD 41, 42, 43, 44	4, 10
LPD 7, 8, 9, 10	9, 10	LHD 1, 2, 3, 4, 5	2, 10, 16, 18
LPD 11, 12, 13, 14, 15	9, 10		
LPH 12	5, 7, 10, 11, 12		
LSD 37, 38, 39, 40	2, 7, 10, 11		

STANDARD SYSTEM VARIATIONS (SEE NOTES 2 AND 3 ON SHEET 1)

* 1. COMMON STEAM PRESSURE SENSING CONNECTION – REQUIRES ONLY ONE STEAM PRESSURE TRANSMITTER (PC NO. 1) AND NO MAXIMUM SIGNAL SELECTOR (PC NO. 2).

* 2. ONE BOILER PER SPACE – REQUIRES ONLY ONE STEAM PRESSURE TRANSMITTER (PC NO. 1). NO MAXIMUM SIGNAL SELECTOR (PC NO. 2), AND A BOILER CONTROL STATION WITHOUT BIAS (PC NO. 14 IN PLACE OF PC NO. 6).

* 3. ONE ELECTRIC DRIVEN FORCED–DRAFT BLOWER PER BOILER – REQUIRES AN INDIVIDUAL FORCED–DRAFT BLOWER CONTROL STATION WITHOUT BIAS (PC NO. 14 IN PLACE OF PC NO. 6). NO FORCED DRAFT BLOWER MASTER CONTROL STATION (PC NO. 14), NO STEAM FLOW RATE RELAY (PC NO. 7) AND NO FORCED DRAFT BLOWER POSITIONER (PC NO. 9).

* 4. WOODWARD GOVERNORS ON FORCED DRAFT BLOWERS – FORCED DRAFT BLOWER POSITIONER (PC NO. 9) IS NOT REQUIRED.

* 5. CONTROL DRIVE ACTUATORS ON FORCED DRAFT BLOWERS – A GENERAL REGULATOR DOUBLE ACTING 5 X 5 PNEUMATIC ACTUATOR, MODEL 10035, OR A GENERAL REGULATOR SINGLE ACTING PNEUMATIC ACTUATOR, MODEL 1801, IS REQUIRED IN PLACE OF FORCED DRAFT BLOWER POSITIONER (PC NO. 9).

6. THREE FORCED DRAFT BLOWERS PER BOILER – REQUIRES AN ADDITIONAL FORCED DRAFT BLOWER CONTROL STATION (PC NO. 6). POSITIONER (PC NO. 9), PRESSURE GAUGE (PC NO. 30), AND AIR LOCK.

7. EXISTING SUPPLY TYPE FUEL OIL VALVE, MODEL 10287 – MODEL 10287 FUEL OIL VALVE IS USED IN PLACE OF MODEL 32028 (PC NO. 19).

8. DELETED

9. AUTOMATIC FEEDWATER CONTROL SYSTEM ONLY. NO AUTOMATIC COMBUSTION CONTROL SYSTEM – COMBUSTION CONTROL SYSTEM COMPONENTS SHOWN ON SHEETS 3 THRU 5 ARE NOT REQUIRED.

B 10. EXISTING COPES VULCAN, LESLIE, OR BAILEY FEEDWATER CONTROL VALVE – FEEDWATER VALVE WITH MODIFIED PARABOLIC OR EQUAL PERCENTAGE TRIM IS USED IN PLACE OF MASONELIAN FEEDWATER CONTROL VALVE (PC NO. 32), AND A 0–60 PSIG PRESSURE GAUGE (PC NO. 30) IS USED IN PLACE OF A 0–30 PSIG GAUGE (PC NO. 29) AND AN ADDITIONAL PC NO. 17 WITH AN S2 IN PLACE OF AN S AIR SUPPLY IS REQUIRED.

* 11. EXISTING COMBUSTION CONTROL SYSTEM WITH NO FORCED DRAFT BLOWER MASTER CONTROL STATION – FORCED DRAFT BLOWER MASTER CONTROL STATION (PC NO. 14) IS NOT REQUIRED.

* 12. VARIABLE INLET VANE FORCED DRAFT BLOWERS – REQUIRES INDIVIDUAL FORCED DRAFT BLOWER CONTROL STATIONS WITHOUT BIAS (PC NO. 14 IN PLACE OF PC NO. 6) AND NO STEAM FLOW RATE RELAY (PC NO. 7).

A * 13. THREE BOILERS PER SPACE WITH SPLIT BOILER CONTROL SYSTEM CAPABILITY – REQUIRES ADDITIONAL COMPONENTS AS SHOWN IN VARIATION 13 ON SHEET 7, INCLUDING AN ADDITIONAL SET OF CONTROL SYSTEM HARDWARE FOR THE THIRD BOILER.

* 14. DELETED

A 15. ONE FORCED DRAFT BLOWER PER BOILER – REQUIRES ONLY ONE INDIVIDUAL FORCED DRAFT BLOWER CONTROL STATION WITHOUT BIAS (PC NO. 14 IN PLACE OF PC NO. 6), ONE SET OF RELATED BLOWER HARDWARE (PC NOS. 9, 17, 30, 31, AND 33) AND NO FORCED DRAFT BLOWER MASTER CONTROL STATION (PC NO. 14).

16. PORT USE FAN AUTOMATIC CAPABILITY-REQUIRES PORT USE FAN AUTO/MAN CONTROL STATION. HAGAN 58-N TOTALIZER, HAGAN 2-1/2 x 5 INCH POWER POSITIONER, 2 ADDITIONAL AIR PRESSURE REGULATORS (PC. NO 17), 2 ADDITIONAL 3-WAY SWITCHING VALVES (PC. NO. 31), 1 ADDITIONAL PSIG GAUGES (PC. NO. 29) AND A 0–200 PSIG PRESSURE GAUGE.

VARIATIONS CONTINUED ON SHEET 10

Figure 225-2-10 General Regulator Automatic Combustion Control and Feedwater Control Systems (Sheet 2 of 11)

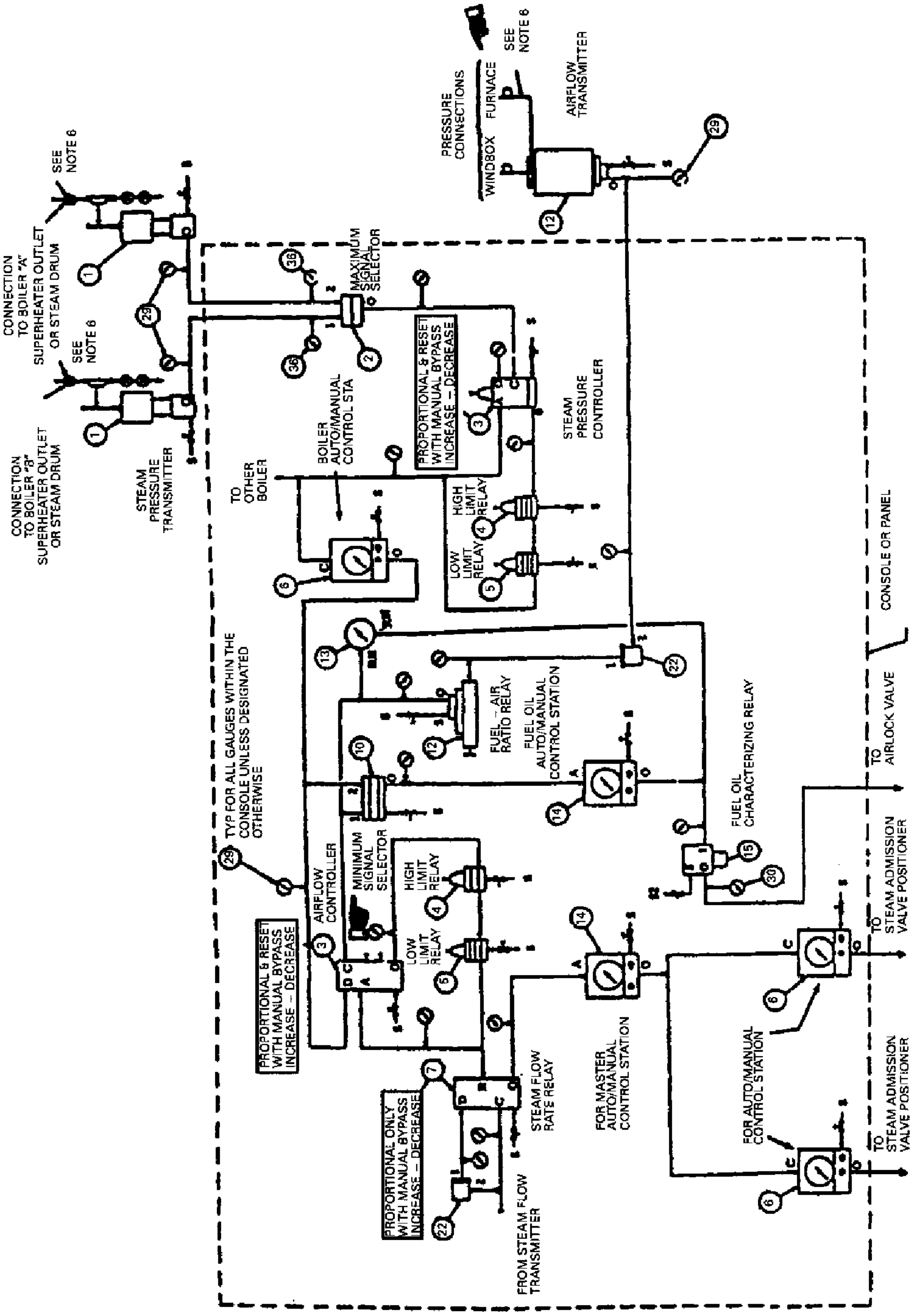


Figure 225-2-10 General Regulator Automatic Combustion Control and Feedwater Control Systems (Sheet 3 of 11)

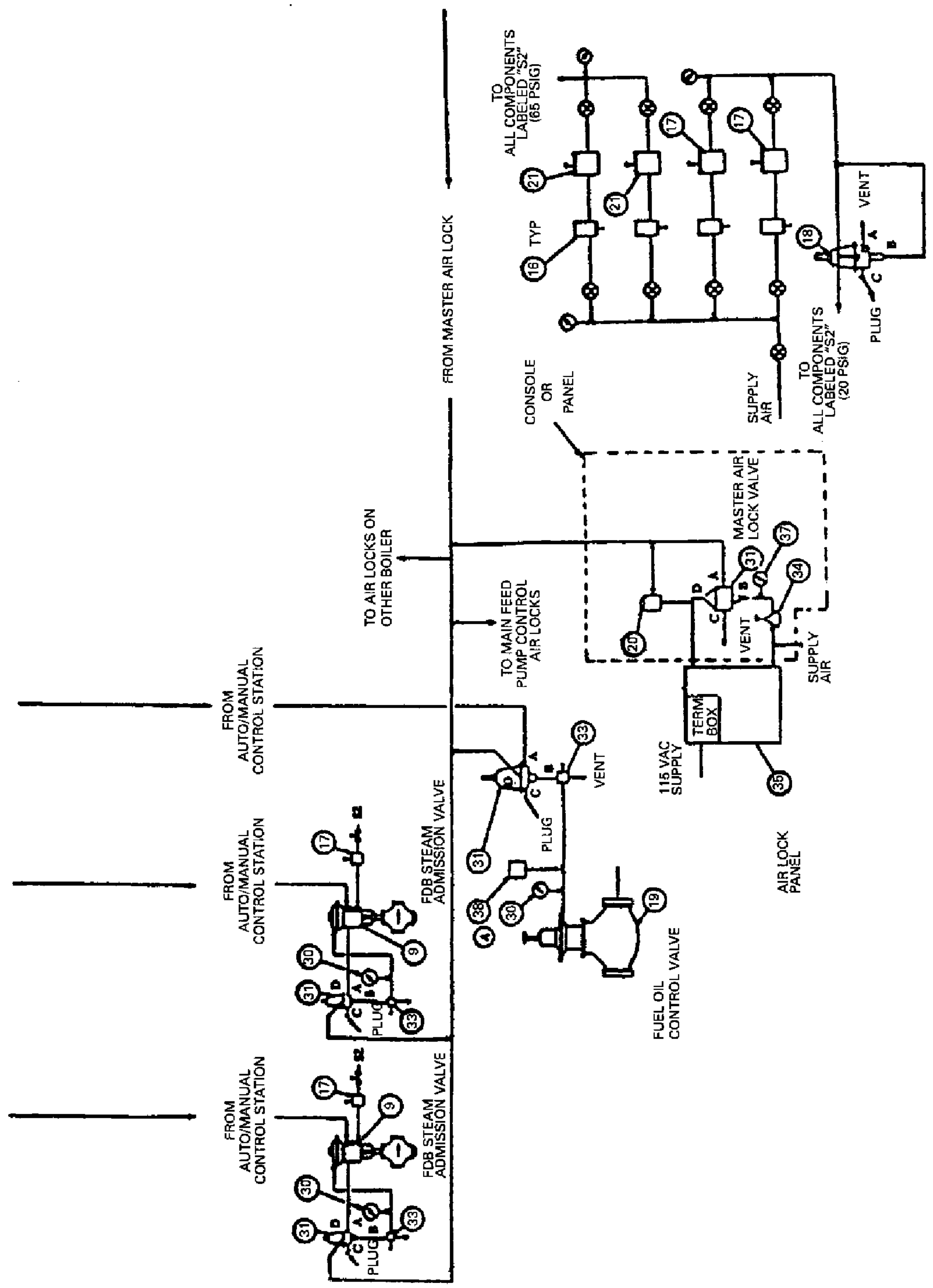


Figure 225-2-10 General Regulator Automatic Combustion Control and Feedwater Control Systems (Sheet 4 of 11)

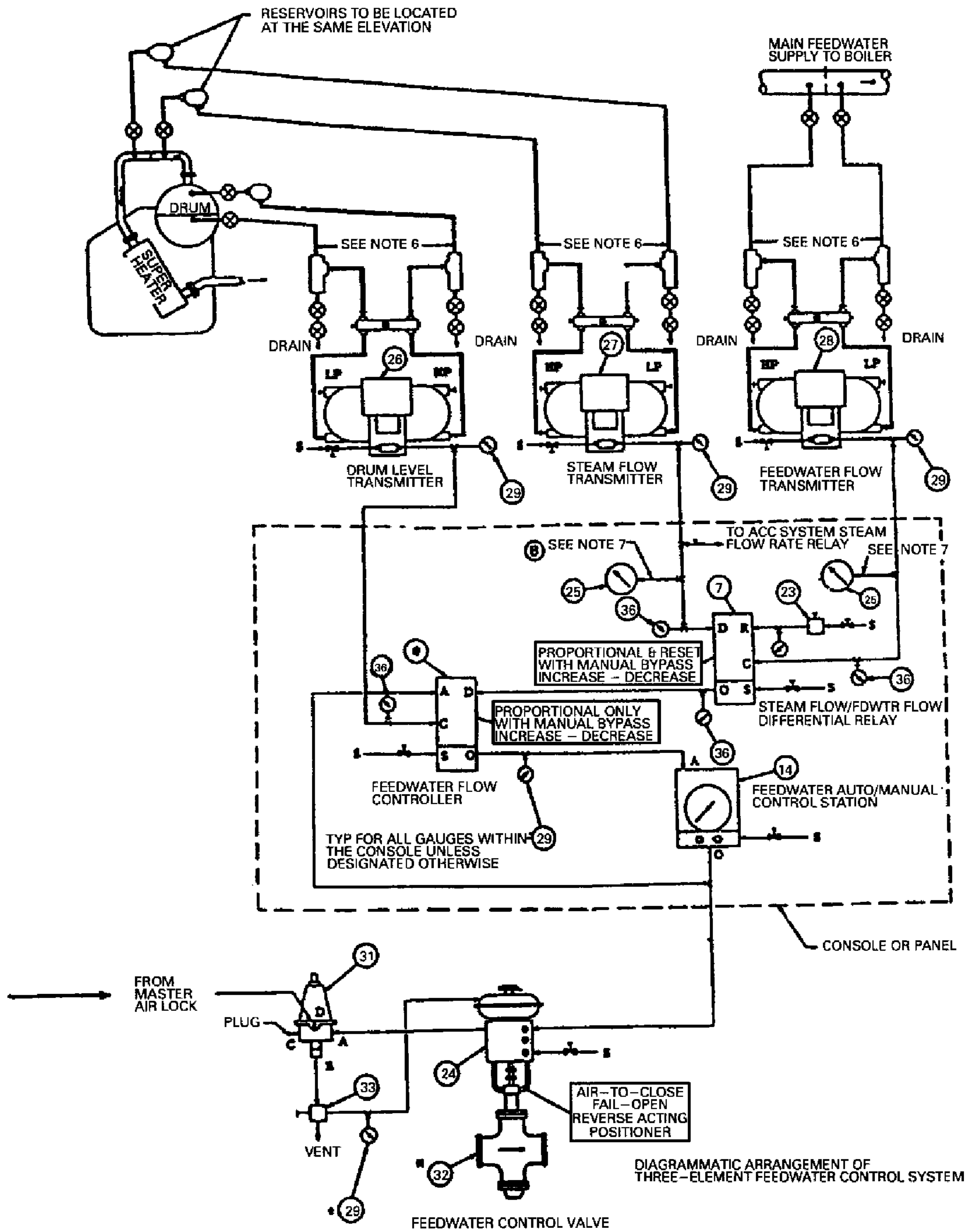
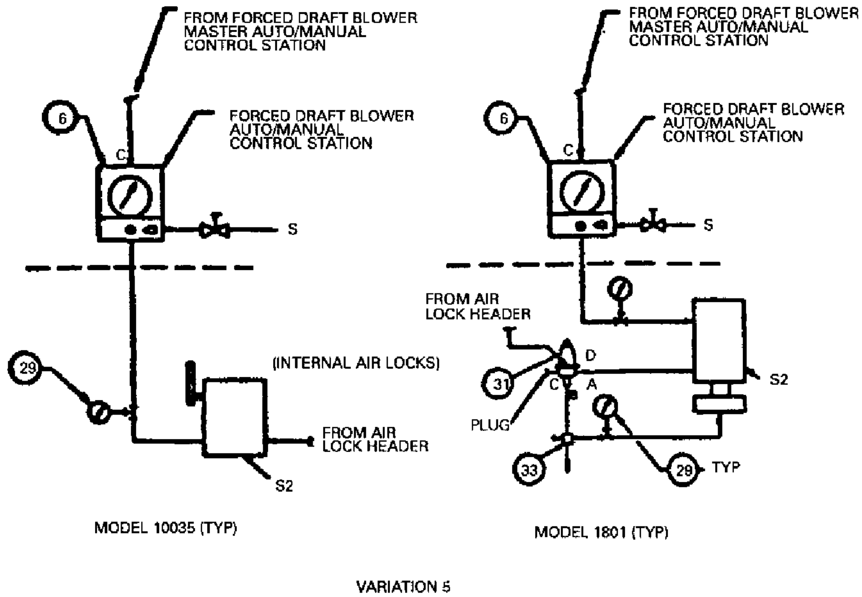


Figure 225-2-10 General Regulator Automatic Combustion Control and Feedwater Control Systems (Sheet 5 of 11)



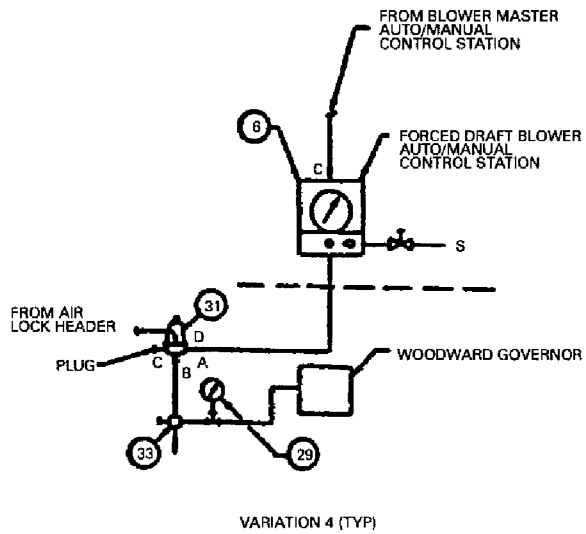


Figure 225-2-10 General Regulator Automatic Combustion Control and Feedwater Control Systems (Sheet 6 of 11)

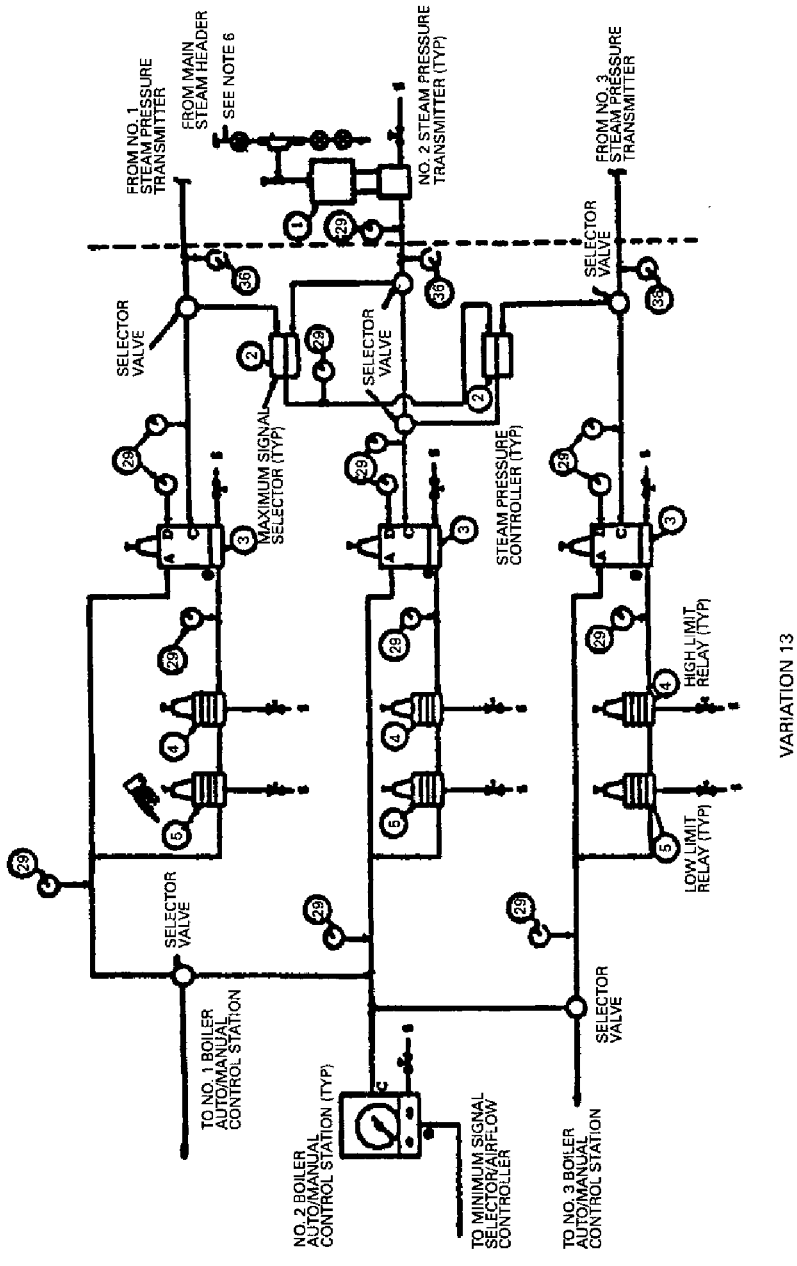


Figure 225-2-10 General Regulator Automatic Combustion Control and Feedwater Control Systems (Sheet 7 of 11)

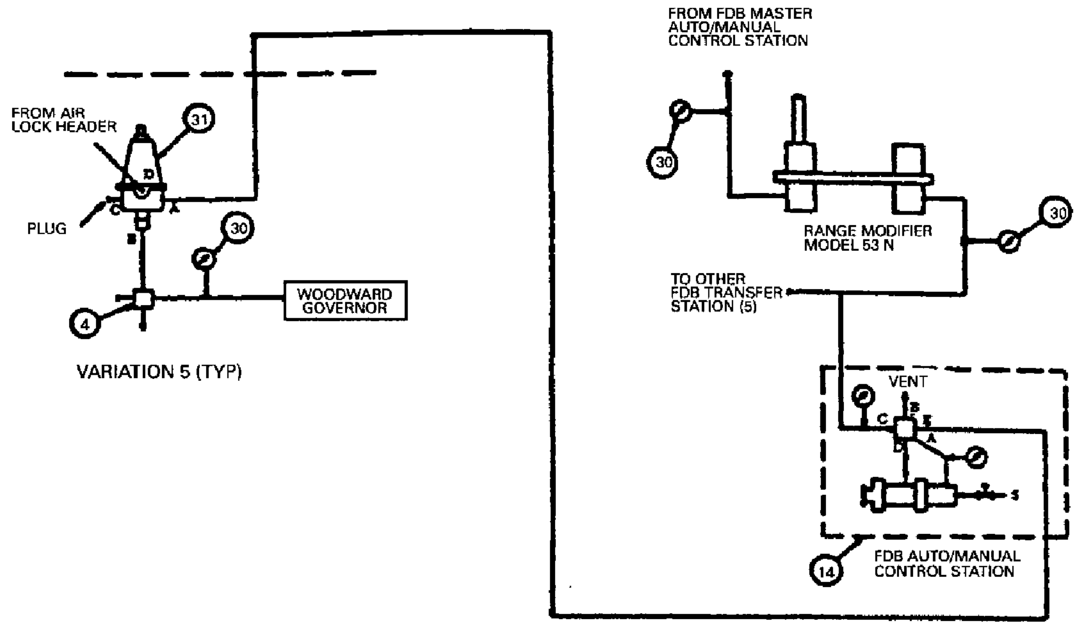


Figure 225-2-10 General Regulator Automatic Combustion Control and Feedwater Control Systems (Sheet 8 of 11)

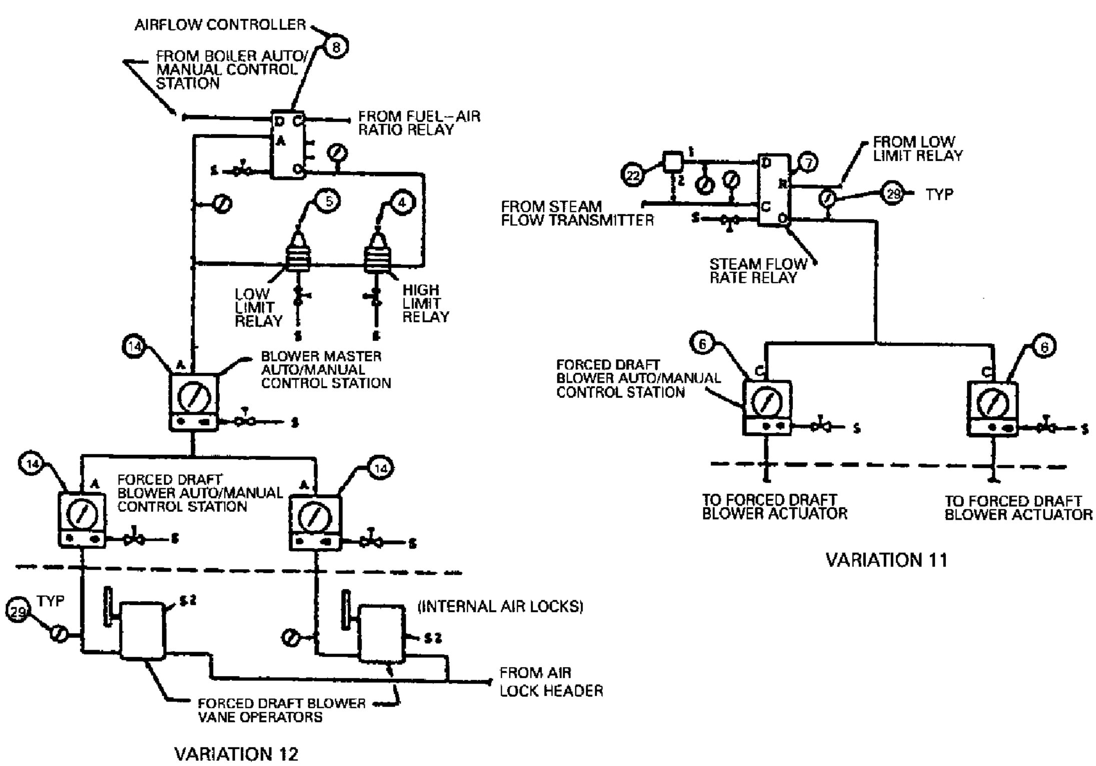


Figure 225-2-10 General Regulator Automatic Combustion Control and Feedwater Control Systems (Sheet 9 of 11)

STANDARD SYSTEM VARIATIONS (CONTINUED FROM SHEET 2)

17 BURNER MANAGEMENT SYSTEM INTERFACES WITH ACC SYSTEM – AN AUTOMATIC PURGE SOLENOID VALVE IS INSTALLED IN THE LINE BETWEEN THE FORCED-DRAFT BLOWER CONTROL STATION AND THE FORCED DRAFT BLOWER ACTUATOR. A PRESSURE SWITCH FOR THE FORCED-DRAFT BLOWER HIGH CIRCUITRY RECEIVES ITS SIGNAL AT A POINT AFTER THE AIRFLOW CONTROLLER LOW LIMIT RELAY.

18 THE STEAM FLOW/FEEDWATER FLOW DIFFERENTIAL RELAY IS A MODEL 50W IN LIEU OF A MODEL 50. THE MODEL 50W HAS A WIDER PROPORTIONAL BAND RANGE OF 5-500.

(D) • 19 THREE BOILERS PER SPACE-REQUIRES THREE STEAM PRESSURE TRANSMITTERS AND TWO MAXIMUM SIGNAL SELECTORS.

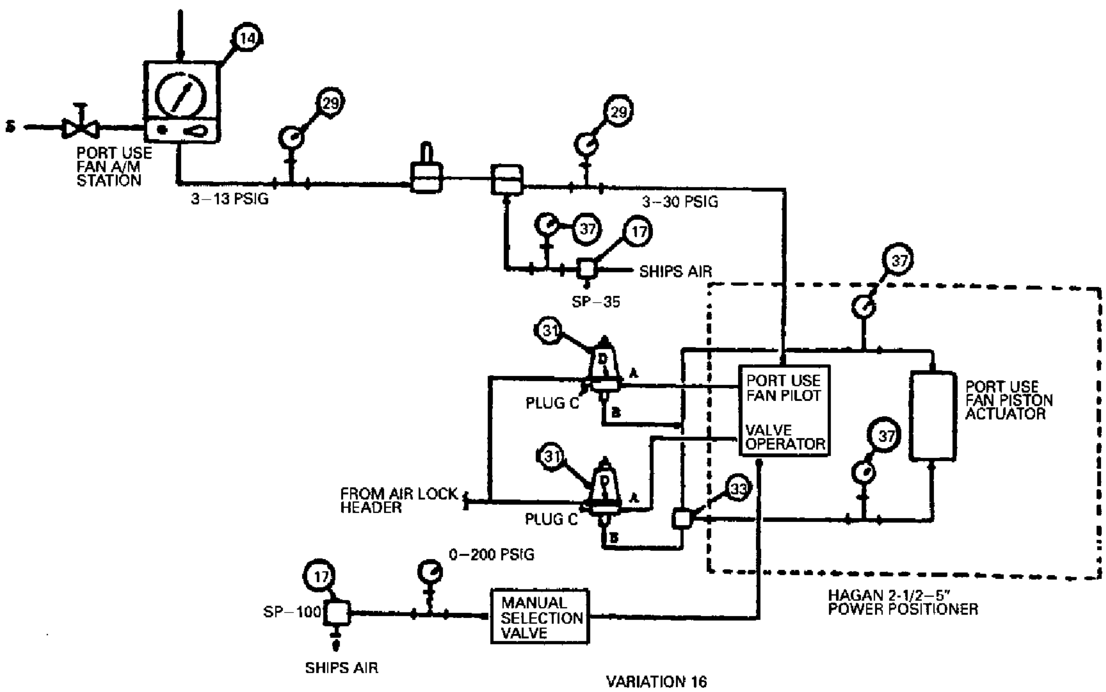


Figure 225-2-10 General Regulator Automatic Combustion Control and Feedwater Control Systems (Sheet 10 of 11)

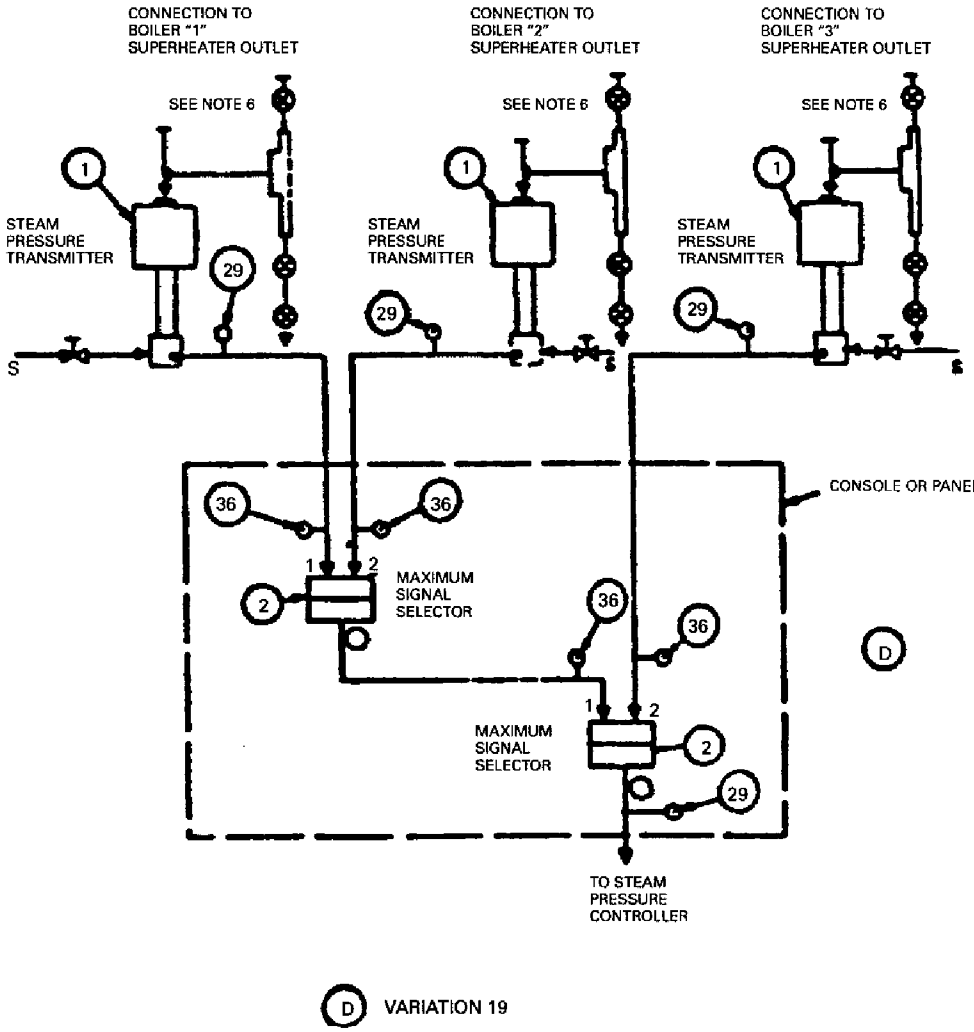


Figure 225-2-10 General Regulator Automatic Combustion Control and Feedwater Control Systems (Sheet 11 of 11)

LIST OF MATERIAL – QUANTITIES PER TYPICAL FIREROOM

	PC NO.	DESCRIPTION	QTY	MANUFACTURER	MODEL OR PART NO.	REMARKS
	1	STEAM PRESSURE TRANSMITTER	2	HAGAN	53N	MASTER SENDER MODIFIED, SEE NOTE 5
	2	MAXIMUM SIGNAL SELECTOR	1	G.W. DAHL CO	71H	
	3	STEAM PRESSURE CONTROLLER	1	HAGAN	58N	
B	4	AIR LOCK VENT VALVE	8	HOKE	7165f43	SEE NOTE 3
	5	STEAM FLOW/FEEDWATER FLOW DIFFERENTIAL RELAY	2	HAGAN	58N	
	6	AUTOMATIC/MANUAL CONTROL STATION (NON-BIAS)	6	HAGAN	53N	DWG NOS 539067–40, 539557–31, AND 539079–7
	7	STEAM FLOW RATE RELAY	2	HAGAN	58N	
	8	AIRFLOW CONTROLLER OR FEEDWATER FLOW CONTROLLER	4	HAGAN	58N	
	9	FORCED-DRAFT BLOWER STEAM ADM. VALVE POSITIONER	4	BAILEY METER CO	AP2920A	
	10	MINIMUM SIGNAL SELECTOR	2	G.W. DAHL CO	71L	
	11	FUEL–AIR RATIO RELAY	2	HAGAN	53N	
	12	AIRFLOW TRANSMITTER	2	HAGAN	53N	
	13	AIR PRESSURE REGULATOR	1	MOORE PROD CO	41–100	
	14	AUTOMATIC/MANUAL CONTROL STATION (BIAS)	6	HAGAN	53N	DWG NOS 539068–40, 539557–30, AND 539079–7
	15	FUEL OIL CHARACTERIZING RELAY	2	GEN REGULATOR DIV	28974–A	
B	16	AIR FILTER, SELF-CLEANING STRAINER, 1/4"	2	LESLIE		DWG NO. 14298N. SEE NOTE 8
	17	1/4" REDUCING VALVE	7	HAGAN	PT NO. 539561	
	18					
	19	FUEL OIL CONTROL VALVE	2	GEN REGULATOR DIV	32028	
	20	AIR LOCK PANEL	1	————	————	NAVSEA DWG 4680421
	21					
	22	NEEDLE VALVE	8	HAGAN		DWG NO. 539384
A	23	VOLUME CHAMBER	9	HAGAN		DWG NO. 577720–001
	24	FEEDWATER CONTROL VALVE POSITIONER	2	BAILEY METER CO	AP2920A	
	25	PRESSURE GAUGE, 2–1/2" DIA. 0–60 PSIG, 1/4" NPT	4	HAGAN		DWG NO. 539079, 0–60 PSIG DIAL
	26	DRUM LEVEL TRANSMITTER, OUTPUT 0–60 PSIG	2	ITT BARTON	274A	
	27	STEAM FLOW TRANSMITTER, OUTPUT 0–60 PSIG	2	ITT BARTON	285/S907	
	28	FEEDWATER FLOW TRANSMITTER, OUTPUT 0–60 PSIG	2	ITT BARTON	285–S907	
	29	PRESSURE REDUCING VALVE	2	MASONEILAN	74–102	OR EQUAL
	30	PRESSURE GAUGE, 2–1/2" DIA. 0–60 PSIG, 1/4" NPT LM	53		NSN 1H–6685–00–246–2365	SEE NOTE 3
B	31	AIR LOCK VALVE	9	FISHER	164A	SEE NOTE 3
	32	FEEDWATER CONTROL VALVE, AIR TO CLOSE NO. 13 ACTUATOR WITH 2–13 TOP MOUNTED HANDWHEEL	2	MASONEILAN	37–10132	WITH EQUAL PERCENTAGE TRIM
	33	PRESSURE GAUGE, 2–1/2" DIA, 0–100 PSIG, 1/4" NPT, LM	1		NSN 1H–6685–00–244–1830	
	34	AIR PRESSURE REGULATOR	4	MOORE PROD CO	40H50	SEE NOTE 3

NOTES:

1. THIS PLAN IS DEVELOPED TO SHOW STANDARDIZED HAGAN ACC/FWC SYSTEM CONFIGURATION.
2. THIS PLAN IS APPLICABLE TO THE SHIPS LISTED UNDER APPLICABLE SHIPS AND VARIATIONS (SHEET 2) AND PROVIDES SUPPLEMENTAL GUIDANCE FOR ACCOMPLISHING CLASS STANDARDIZATION SHIPALTS. THE DEGREE OF STANDARDIZATION IS LIMITED IN SCOPE. FOLLOWING ACCOMPLISHMENT OF APPLICABLE SHIPALTS THE VARIATIONS FROM THE STANDARD SYSTEM LISTED UNDER APPLICABLE SHIPS AND VARIATIONS WILL REMAIN.
3. ALL QUANTITIES SHOWN IN LIST OF MATERIAL ARE FOR TYPICAL FIREROOM AS DEPICTED ON SHEETS 3 & 4. THESE QUANTITIES WILL VARY ACCORDING TO REQUIREMENTS LISTED FOR THE STANDARD SYSTEM VARIATIONS. QUANTITY CHANGES FOR PC NOS. 14, 30, 31, AND 34 SHALL ALSO BE MADE AS REQUIRED BY THE SYSTEM VARIATIONS.
4. ALL VARIATIONS PRECEDED BY * ARE DEPICTED ON SHEETS 5 THRU 9.
5. MODIFIED FROM A PROPORTIONAL PLUS RESET STEAM PRESSURE CONTROLLER TO A PROPORTIONAL ONLY STEAM PRESSURE TRANSMITTER. FOR DETAILS OF THE MODIFICATION SEE APPLICABLE ACC/FWC SYSTEM SHIP ALTERATIONS.
6. (A) ALL SENSING PIPING TO BE INSTALLED ACCORDING TO NAVSECPHILA DRAWING NO. 4182, REVISION H, STEAM GENERATING PLANT (NON–NUCLEAR) AUTOMATIC CONTROL TRANSMITTER PRESSURE SENSING PIPING.
7. (B) CUTOUT VALVES ASSOCIATED WITH PC NO. 25 ARE NOT ESSENTIAL. THESE VALVES, IF ALREADY INSTALLED IN EXISTING SYSTEM, MAY BE RETAINED.
8. LATER INSTALLATION OR REPLACEMENT USE CUNO MODEL CT101 AIR FILTERS IN PLACE OF LESLIE 14298H.

Figure 225-2-11 Hagan Automatic Combustion Control and Feedwater Control (Sheet 1 of 8)

APPLICABLE SHIPS AND VARIATIONS	
SHIP CLASS	**VARIATIONS**
CV-67	1, 3, 5, 8
LKA 113, 114, 115, 116, 117	1, 4, 6, 8, 9
LSD 36	2, 8
B AFS 4, 5, 6, 7	1, 5, 11, 12, 13

STANDARD SYSTEM VARIATIONS (SEE NOTES 2 & 3 ON SHEET 1)

- 1. COMMON STEAM PRESSURE SENSING CONNECTION. REQUIRES ONLY ONE STEAM PRESSURE TRANSMITTER (PC NO. 1) AND NO MAXIMUM SIGNAL SELECTOR (PC NO. 2).
- 2. ONE BOILER PER SPACE - REQUIRES ONLY ONE STEAM PRESSURE TRANSMITTER (PC NO. 1), NO MAXIMUM SIGNAL SELECTOR (PC NO. 2), AND A NON-BIASING BOILER CONTROL STATION (PC NO. 6) IN PLACE OF BIASING STATION (PC NO. 14).
- 3. THREE FORCED-DRAFT BLOWERS PER BOILER-REQUIRES AN ADDITIONAL FORCED-DRAFT BLOWER STATION (PC NO. 14) AND POSITIONER (PC NO. 9).
- 4. VARIABLE INLET VANE FORCED-DRAFT BLOWERS-REQUIRES NO STEAM FLOW RATE RELAY (PC NO. 7) AND NON-BIASING FORCED-DRAFT BLOWER CONTROL STATIONS (PC NO. 6) IN PLACE OF BIASING STATIONS (PC NO. 14).
- 5. WOODWARD GOVERNORS ON FORCED-DRAFT BLOWERS-FORCED-DRAFT BLOWER POSITIONER (PC NO. 9) IS NOT REQUIRED AND FORCED-DRAFT BLOWER SIGNAL RANGE MODIFIER IS UTILIZED.
- 6. CONTROL DRIVE ACTUATORS ON FORCED-DRAFT BLOWERS - A HAGAN DOUBLE ACTING 5 BY 10 PNEUMATIC ACTUATOR, MODEL 53-N, OR A GENERAL REGULATOR SINGLE ACTING PNEUMATIC ACTUATOR, MODEL 1801, WITH SIGNAL RANGE MODIFIER IS USED IN PLACE OF FORCED-DRAFT BLOWER POSITIONER (PC NO. 9).
- 7. DELETED
- 8. EXISTING MASONEILAN OR COPES VULCAN FEEDWATER CONTROL VALVE – EXISTING FEEDWATER VALVE WITH EQUAL PERCENTAGE TRIM IS USED IN PLACE ON SPECIFIED FEEDWATER VALVE (PC NO. 32).
- 9. BURNER MANAGEMENT SYSTEM INTERFACES WITH ACC SYSTEM – AN AUTOMATIC PURGE SOLENOID VALVE IS INSTALLED IN THE LINE BETWEEN THE FORCED-DRAFT BLOWER CONTROL STATION AND THE FORCED-DRAFT BLOWER ACTUATOR AND AN AIR LOCK VALVE (PC NO. 31) IS INSTALLED IN THE LINE BETWEEN THE AIR LINE LUBRICATOR AND HEADER FUEL OIL BALL VALVE.
- 10. DELETED

B
- 11. THREE BOILERS PER SPACE REQUIRES AN ADDITIONAL SET OF CONTROL SYSTEM HARDWARE.

B
- 12. LESLIE MODEL DBOYNS FEEDWATER CONTROL VALVE IS USED IN PLACE OF SPECIFIED FEEDWATER VALVE (PC NO. 32) PLACE.

B
- 13. ONE FORCED-DRAFT BLOWER WITH WOODWARD GOVERNOR PER BOILER-REQUIRES ONLY ONE FORCED-DRAFT BLOWER CONTROL STATION WITHOUT BIAS (PC NO. 6 IN PLACE OF PC NO. 14) ONE SET OF RELATED BLOWER HARDWARE (PC NOS. 4, 30 AND 31), AND NO FORCED-DRAFT BLOWER MASTER CONTROL STATION (PC NO. 6). A SIGNAL RANGE MODIFIER IS UTILIZED BETWEEN THE OUTPUT OF FDB A/M STATION (PC NO. 6) AND THE WOODWARD GOVERNOR.

Figure 225-2-11 Hagan Automatic Combustion Control and Feedwater Control (Sheet 2 of 8)

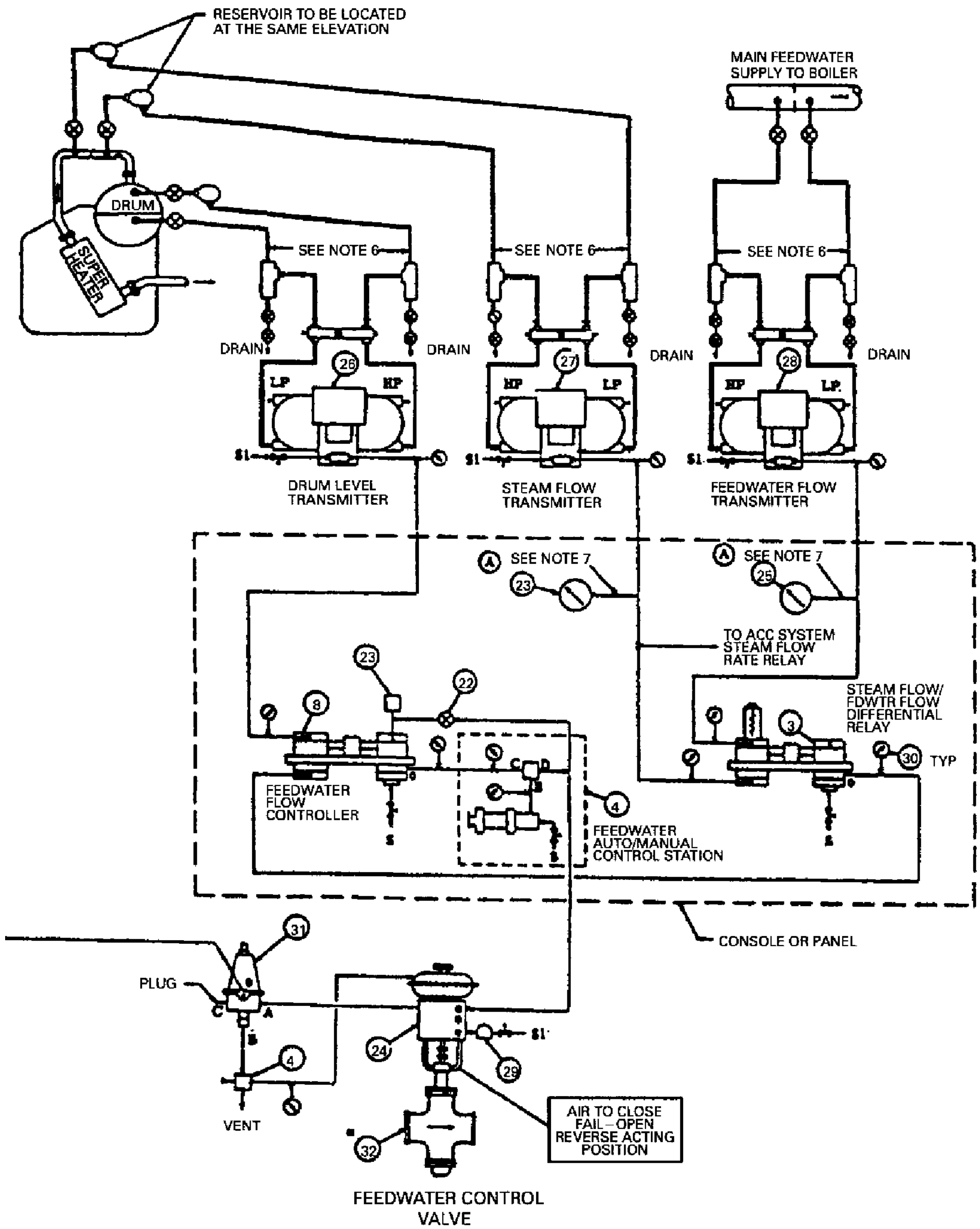


Figure 225-2-11 Hagan Automatic Combustion Control and Feedwater Control (Sheet 3 of 8)

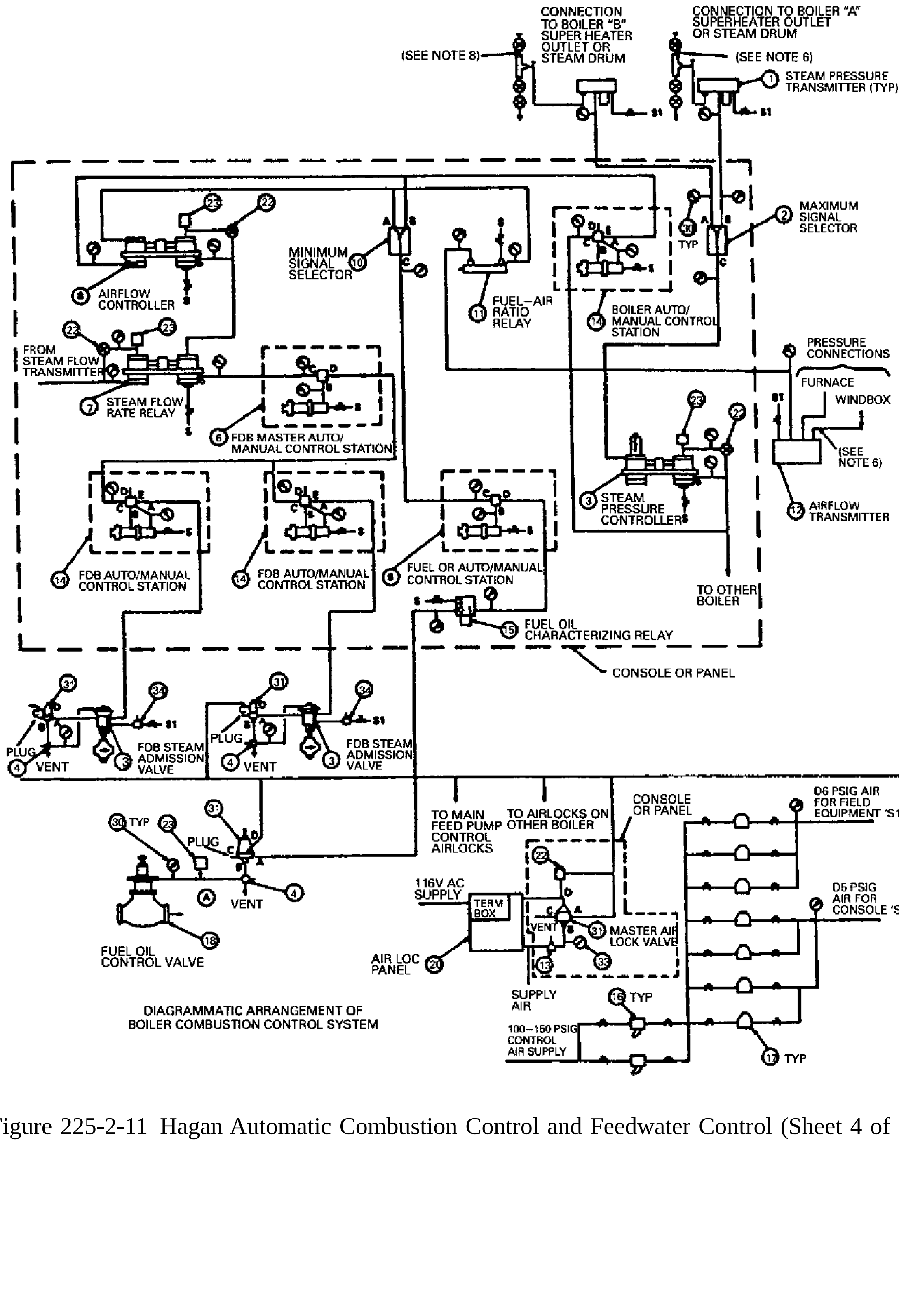


Figure 225-2-11 Hagan Automatic Combustion Control and Feedwater Control (Sheet 4 of 8)

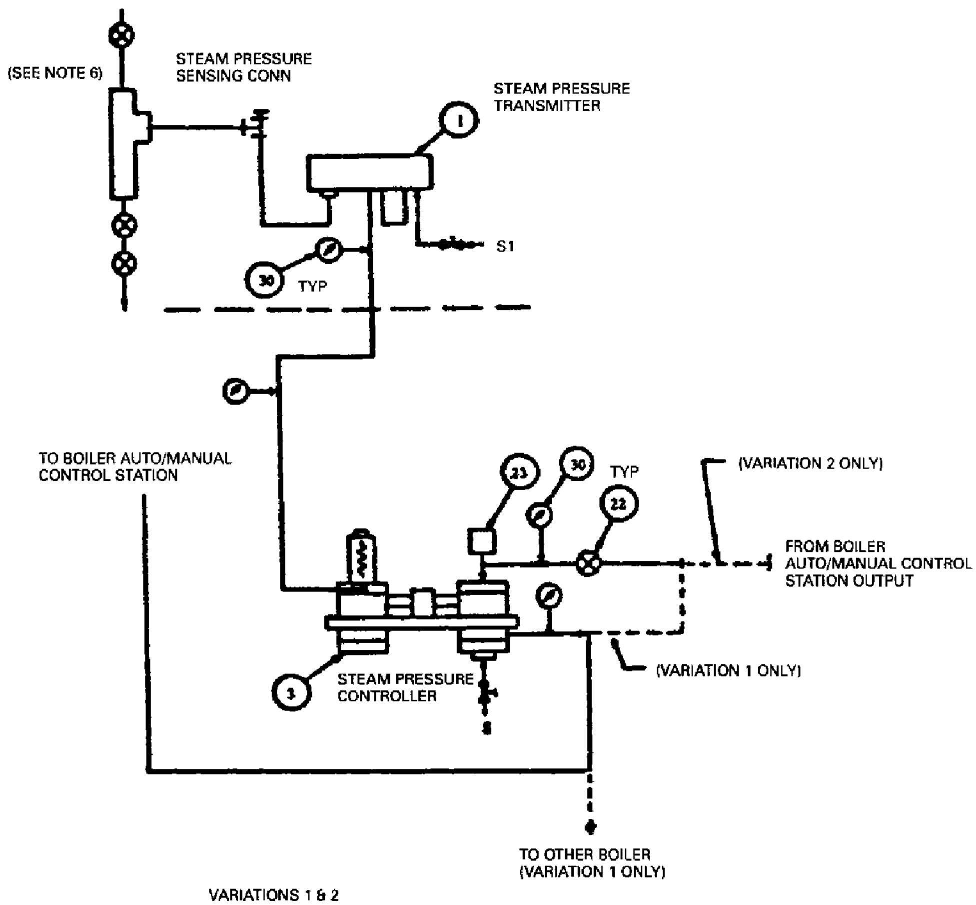


Figure 225-2-11 Hagan Automatic Combustion Control and Feedwater Control (Sheet 5 of 8)

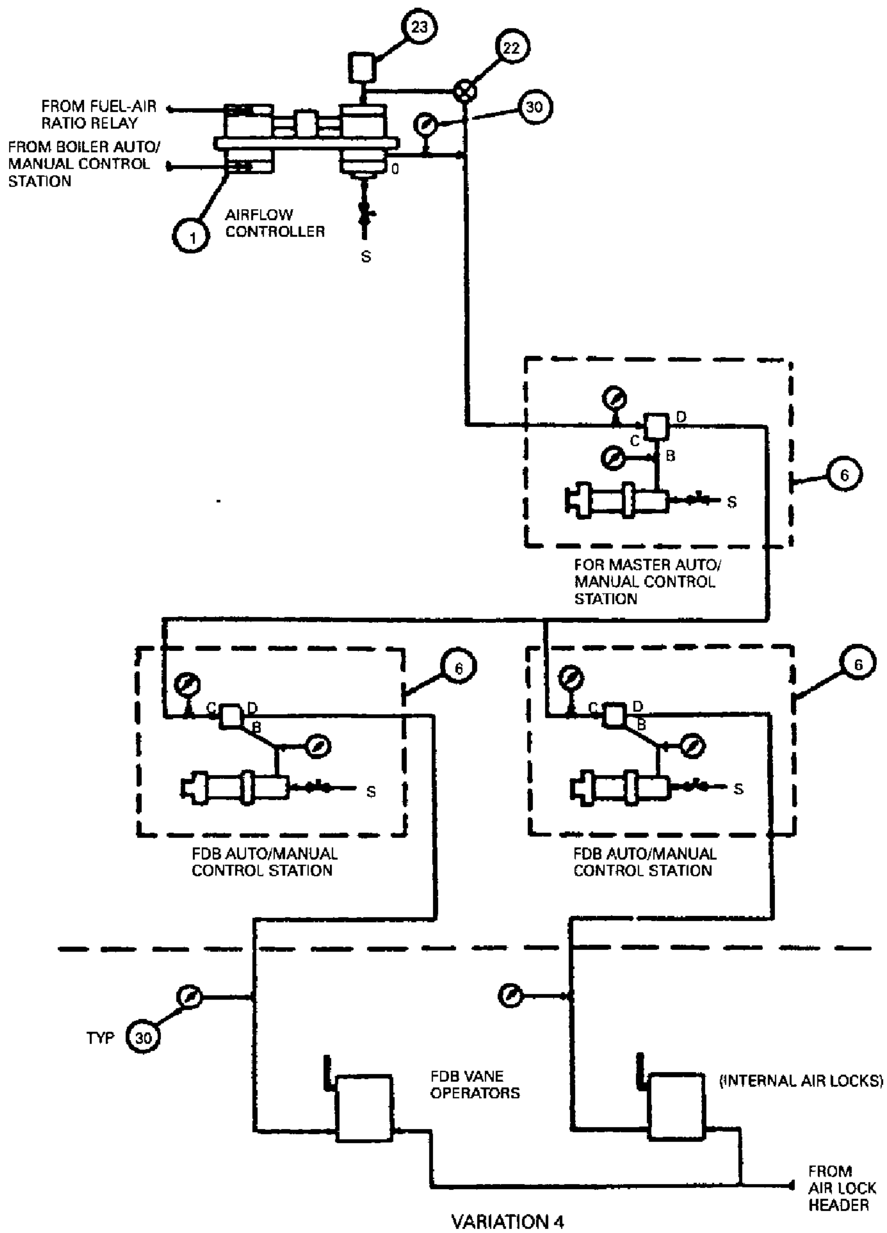
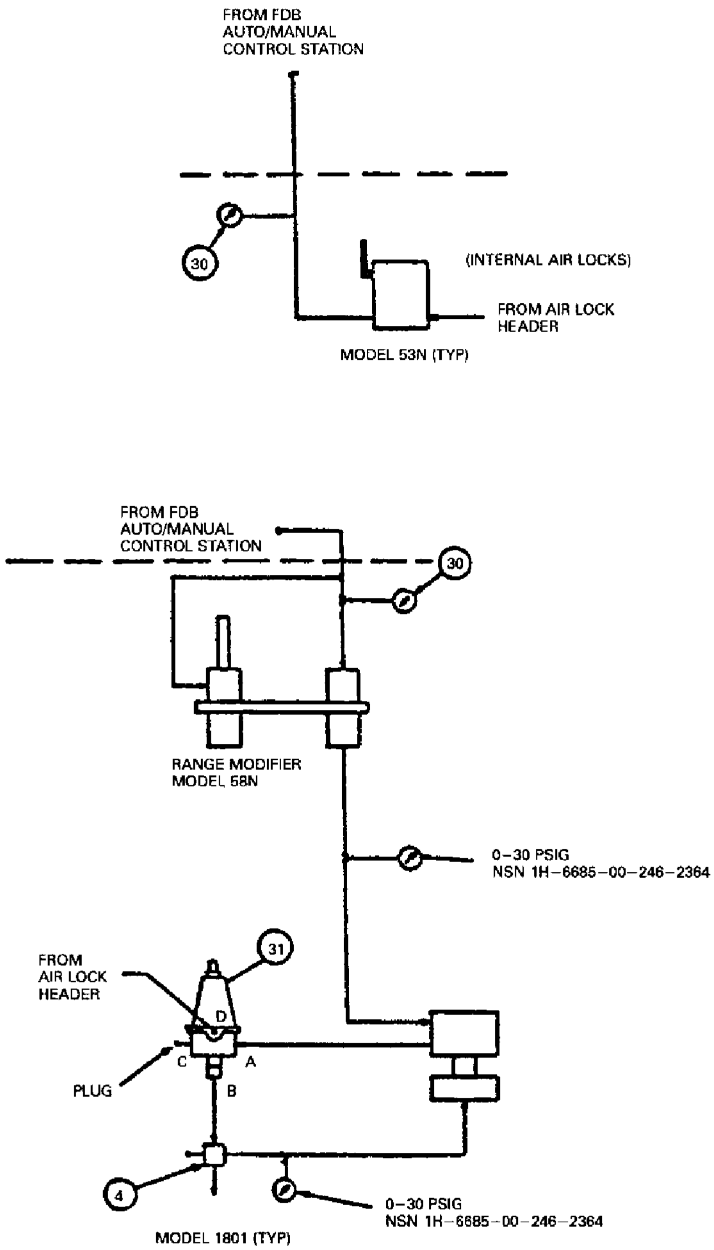


Figure 225-2-11 Hagan Automatic Combustion Control and Feedwater Control (Sheet 6 of 8)



VARIATION 6

Figure 225-2-11 Hagan Automatic Combustion Control and Feedwater Control (Sheet 7 of 8)

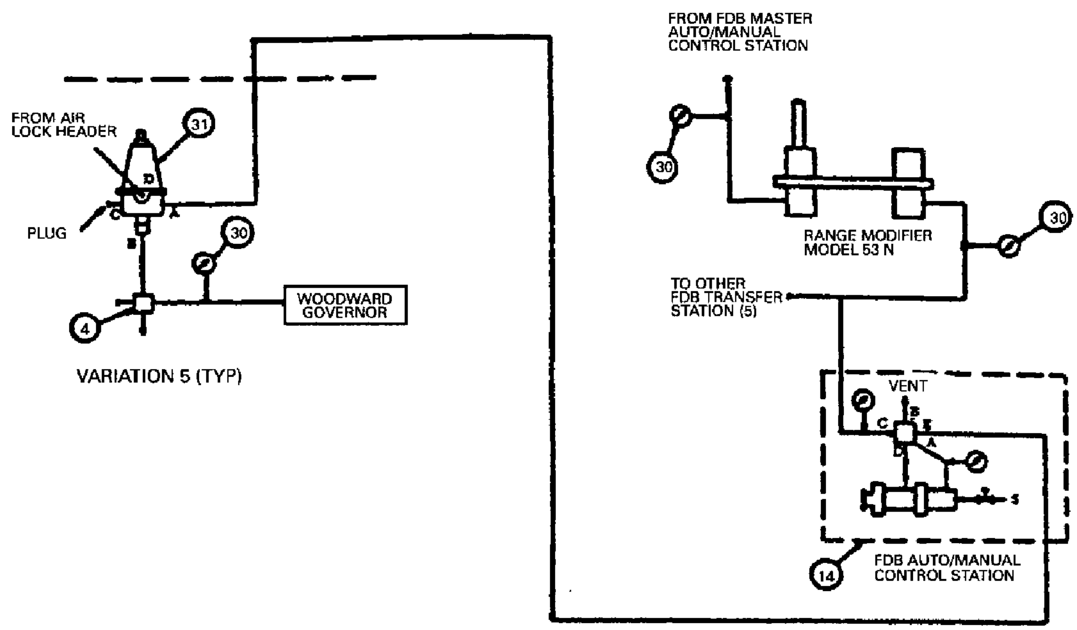


Figure 225-2-11 Hagan Automatic Combustion Control and Feedwater Control (Sheet 8 of 8)

LIST OF MATERIAL – QUANTITIES PER TYPICAL FIREROOM					
PC NO.	DESCRIPTION	QTY	MANUFACTURER	MODEL OR PART NO.	REMARKS
1	HEADER PRESSURE TRANSMITTER	1	MOORE PROD CO	MODEL 1735-M44	INPUT 900–1600 PSIG OR 500–1000 PSIG
2	HEADER PRESSURE CONTROLLER	1	GEN REG DIV	55	DWG NO 10140
3	AUTOMATIC/MANUAL CONTROL STATION	3	–	30241	WITHOUT BIAS
4	AIR FILTER	3	–	30282	
5	AIR PRESSURE REGULATOR	3	MOORE PROD CO	40H50	
6	FEED PUMP ACTUATOR POSITIONER	3	–	72G315R	
7	AIR LOCK VALVE	3	FISHER	164A	FIELD MOUNTED
8	AIR LOCK VENT VALVE	3	HOKE	7165F48	FIELD MOUNTED
9	PRESSURE GAUGE 2-1/2" DIA, 0-15 PSIG, 1/4 NPT, LM	1		NSN 1H-6685-00-246-2363	
10	PRESSURE GAUGE: 2-1/2" DIA, 0-30 PSIG, 1/4" NPT, LM	1		NSN 1H-6685-00-246-2364	
11	PRESSURE GAUGE, 2-1/2" DIA, 0-60 PSIG, 1/4" NPT, LM	4		NSN 1H-6685-00-246-2365	

APPLICABLE SHIPS AND VARIATIONS	
SHIP CLASS	VARIATIONS
AD 37, 38	2, 3
AE 28, 29	1, 2
AE 32, 33, 34, 35	1, 2
AFS 1, 2, 3	1, 2
CV 64	NONE
LPD 7, 8	1, 2

STANDARD SYSTEM VARIATIONS (SEE NOTE 2)

1. TWO MAIN FEED PUMPS PER FIREROOM – REQUIRES ONLY TWO CONTROL STATIONS (PC NO. 3), TWO POSITIONERS (PC NO. 6), TWO AIR LOCK VALVES (PC NO. 7), TWO VENT VALVES (PC NO. 8), AND THREE PRESSURE GAUGES (PC NO. 11).

2. WOODWARD GOVERNORS WITH 25-5 PSIG CONTROL SIGNAL RANGE – A MOORE PRODUCTS COMPANY MODEL 55-2 SIGNAL RANGE MODIFIER WITH TWO 0-30 PSIG PRESSURE GAUGES (PC NO. 10) IS USED. POSITIONER (PC NO. 6) IS NOT REQUIRED AND A 0-30 PSIG PRESSURE GAUGE (PC NO. 10) IS USED IN PLACE OF A 0-60 PSIG PRESSURE GAUGE (PC NO. 11) FOR EACH MAIN FEED PUMP. AIR SUPPLY COMPONENTS ARE INSTALLED INSIDE THE CONTROL PANEL. 51 AIR SUPPLY COMPONENTS ARE MOUNTED EXTERNAL TO THE CONSOLE. SEE SKETCH VARIATION 2 (TYP).

3. SPLIT MAIN FEED PUMP OPERATION CAPABILITY – SENSING LOCATION IS FEED PUMP DISCHARGE IN PLACE OF COMMON HEADER AND A TRANSMITTER (PC NO. 1), A 0-15 PSIG PRESSURE GAUGE (PC NO. 9), AND A PRESSURE CONTROLLER (PC NO. 2) ARE PROVIDED FOR EACH FEED PUMP.

Figure 225-2-12 General Regulator Feed Pump Controls (sheet 1 of 3)

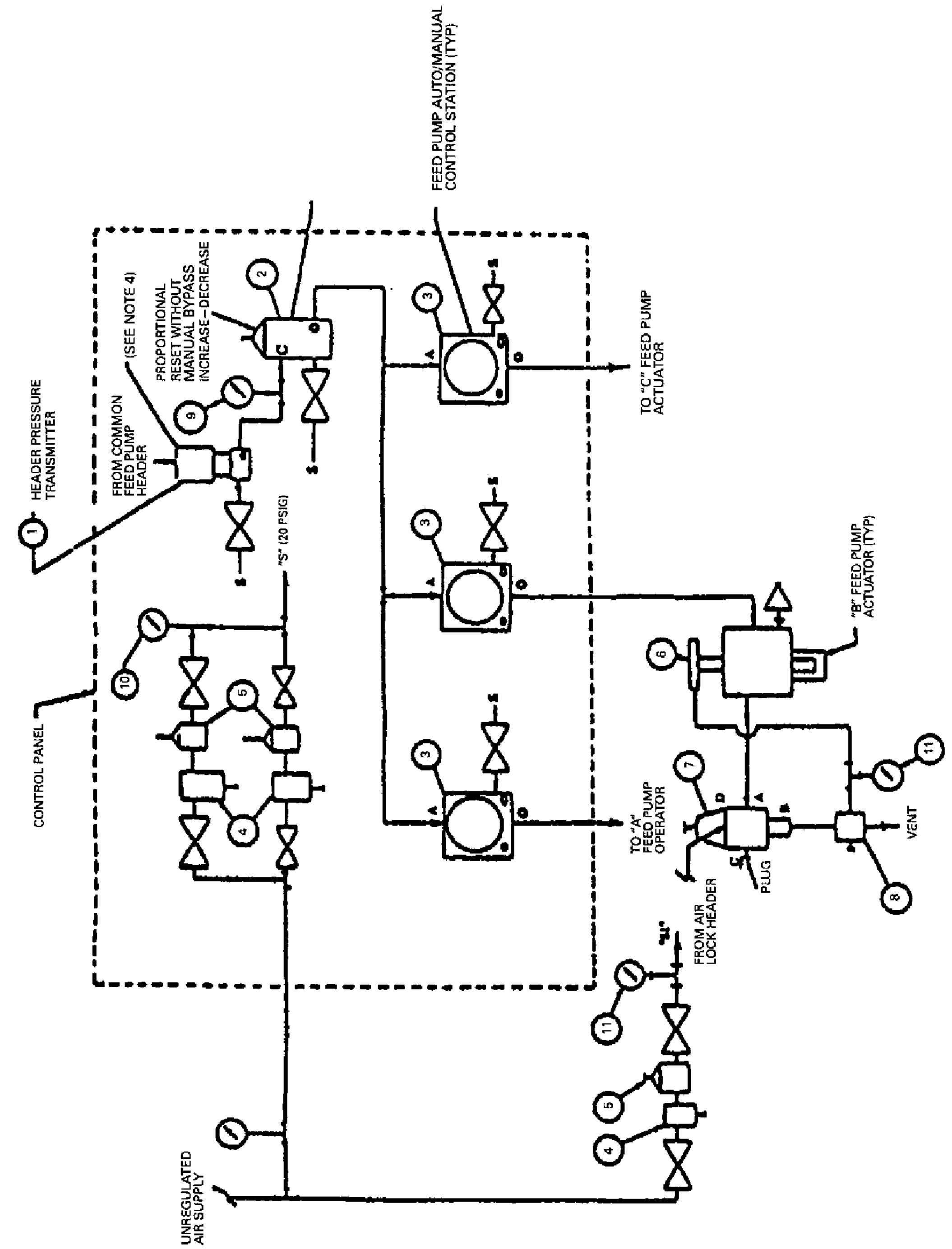
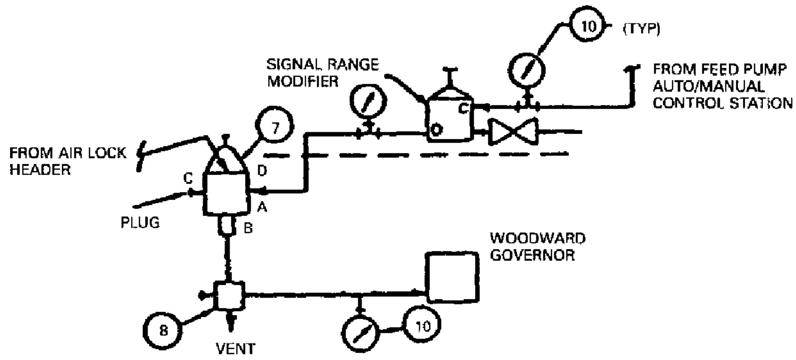


Figure 225-2-12 General Regulator Feed Pump Controls (sheet 2 of 3)



VARIATION 2 (TYP)

NOTES:

1. THIS PLAN DEVELOPED TO SHOW STANDARDIZED GENERAL REGULATOR FPC SYSTEMS CONFIGURATION.

2. ALL QUANTITIES SHOWN IN LIST OF MATERIAL ARE FOR A TYPICAL FIREROOM AS DEPICTED. THESE QUANTITIES WILL VARY IN ACCORDANCE WITH REQUIREMENTS LISTED FOR THE STANDARD SYSTEM VARIATIONS.

3. THIS PLAN IS APPLICABLE TO THE SHIPS LISTED UNDER APPLICABLE SHIPS AND VARIATIONS ON SHEET 1 AND PROVIDES SUPPLEMENTAL GUIDANCE FOR ACCOMPLISHING CLASS STANDARDIZATION SHIPALTS. THE DEGREE OF STANDARDIZATION IS LIMITED IN SCOPE. FOLLOWING ACCOMPLISHMENT OF APPLICABLE SHIPALTS THE VARIATIONS FROM THE STANDARD SYSTEM LISTED UNDER APPLICABLE SHIPS AND VARIATIONS WILL REMAIN.

4. ALL SENSING PIPING TO BE INSTALLED IN ACCORDANCE WITH NAVSECPHILA DRAWING 4182 REV. H STEAM GENERATING PLANT (NON-NUCLEAR) AUTOMATIC CONTROL TRANSMITTER PRESSURE SENSING PIPING.

Figure 225-2-12 General Regulator Feed Pump Controls (sheet 3 of 3)

LIST OF MATERIAL – QUANTITIES PER TYPICAL FIREROOM					
PC NO.	DESCRIPTION	QTY	MANUFACTURER	MODEL OR PART NO.	REMARKS
1	HEADER PRESSURE CONTROLLER	1	HAGAN	53N	MASTER SENDER MODIFIED
2	VOLUME CHAMBER	1	HAGAN		DWG NO. 577720-002 (OR 539542)
3	AUTOMATIC/MANUAL CONTROL STATION (NON-BIAS)	3	HAGAN	53N	DWG NO. 539067-41 539557-318, 539079-8
4	1/4" AIR FILTER	2	LESLIE		DWG NO. 14298N (OR HAGAN DWG NO. 539562)
5	1/4" REDUCING VALVE	2	HAGAN	PT NO. 539561	
6	AIR LOCK VALVE	3	FISHER	164A	FIELD MOUNTED
7	AIR LOCK VENT VALVE	3	HOKE	H 7165F-48	FIELD MOUNTED
8	PRESSURE GAUGE, 2-1/2" DIA., 0-100 PSIG, 1/4" NPT, LM	1		NSN 1H-6065-00-244-1830	
9	PRESSURE GAUGE, 2-1/2" DIA., 0-60 PSIG, 1/4" NPT, LM	3		NSN-1H-5685-00-248-2385	

APPLICABLE SHIPS AND VARIATIONS	
SHIP CLASS	VARIATIONS
AOE	2
B CV 63	NONE
CV 67	NONE
LCC 19, 20	5
LKA 113, 114, 115, 116, 117	1, 4
B LPH 12	5
A AO 177, 178, 179, 180, 181	1, 4
B AFS 4, 5, 6, 7	1, 5

STANDARD SYSTEM VARIATIONS (SEE NOTE 2 ON SHEET 3)

1. TWO MAIN FEED PUMPS PER FIREROOM–REQUIRES ONLY TWO CONTROL STATIONS (PC NO. 3), TWO AIR LOCK VALVES (PC NO. 6). TWO VENT VALVES (PC NO. 7), AND TWO PRESSURE GAUGES (PC NO. 9).

2. ONE CONTROL SYSTEM PER FEED PUMP–REQUIRES AN ENTIRE CONTROL SYSTEM (WITH ONE EACH OF PC NOS 3, 6, 7, AND 9) FOR EACH FEED PUMP.

3. DELETED

B 4. FEED PUMP ACTUATORS WITH 48, 7-15 PSIG CONTROL SIGNAL RANGE – A HAGAN TOTALIZER, MODEL 58N, AND TWO ADDITIONAL 0-60 PSIG PRESSURE GAUGES (PC NO. 9) ARE USED. SEE SKETCH VARIATION 4/5. ONE OF THE REDUCING VALVES (PC NO. 3), UTILIZING AN ADDITIONAL 0-60 PSIG PRESSURE GAUGE (PC NO. 9), SUPPLIES THE TOTALIZER AND THE CONTROL STATIONS WITH 50 PSIG SUPPLY AIR.

B 5. THE WOODWARD GOVERNORS WITH 25-5 CONTROL SIGNAL RANGE – A HAGAN TOTALIZER, MODEL 58N, AND TWO ADDITIONAL 0-60 PSIG PRESSURE GAUGES (PC NO.9) ARE USED. SEE SKETCH VARIATIONS 4/5. ONE OF THE REDUCING VALVES (PC NO. 5), UTILIZING AN ADDITIONAL 0-60 PRESSURE GAUGE (PC NO. 9), SUPPLIES THE TOTALIZER AND CONTROL STATIONS WITH 27 PSIG SUPPLY AIR. THE CONTROL STATION GAUGE DRAWING NUMBER IS 539079–14 IN PLACE OF 539079–8.

B 6. DELETED

Figure 225-2-13 Hagan Feedwater Header Pressure Control System (sheet 1 of 3)

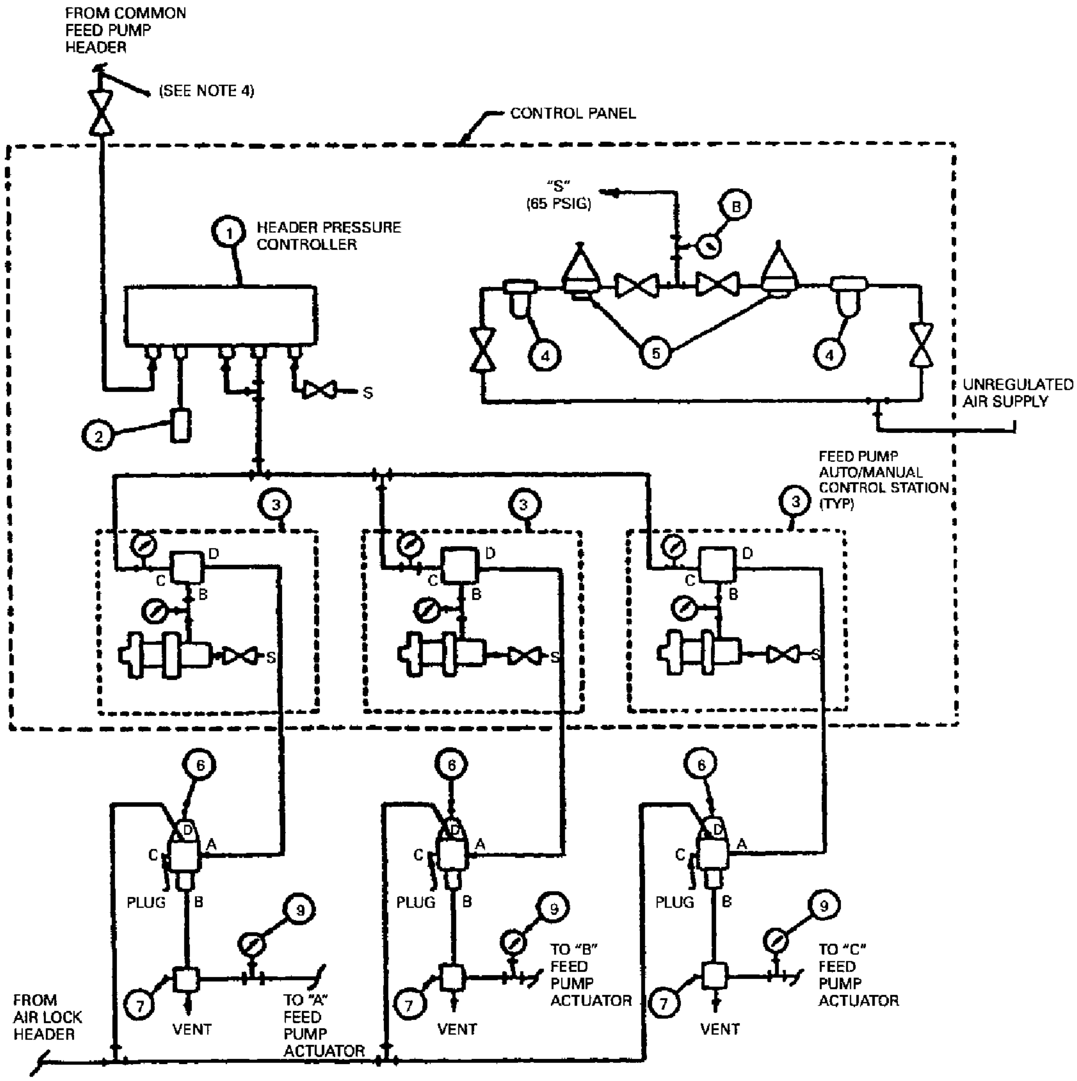
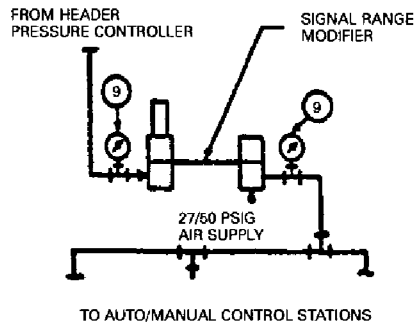


Figure 225-2-13 Hagan Feedwater Header Pressure Control System (sheet 2 of 3)



VARIATIONS 4 & 5

NOTES:

1. THIS PLAN DEVELOPED TO SHOW STANDARDIZED HAGAN FPC SYSTEMS CONFIGURATION.
2. ALL QUANTITIES SHOWN IN LIST OF MATERIAL ARE FOR A TYPICAL FIREROOM AS DEPICTED. THESE QUANTITIES WILL VARY IN ACCORDANCE WITH REQUIREMENTS LISTED FOR THE STANDARD SYSTEM VARIATIONS.
3. THIS PLAN IS APPLICABLE TO THE SHIPS LISTED UNDER APPLICABLE SHIPS AND VARIATIONS ON SHEET 1 AND PROVIDES SUPPLEMENTAL GUIDANCE FOR ACCOMPLISHING CLASS STANDARDIZATION SHIPALTS. THE DEGREE OF STANDARDIZATION IS LIMITED IN SCOPE. FOLLOWING ACCOMPLISHMENT OF APPLICABLE SHIPALTS THE VARIATIONS FROM THE STANDARD SYSTEM LISTED UNDER APPLICABLE SHIPS AND VARIATIONS WILL REMAIN.
4. ALL SENSING PIPING TO BE INSTALLED IN ACCORDANCE WITH NAVSECPHILA DRAWING 4182 REV. H STEAM GENERATING PLANT (NON-NUCLEAR) AUTOMATIC CONTROL TRANSMITTER PRESSURE SENSING PIPING.

Figure 225-2-13 Hagan Feedwater Header Pressure Control System (sheet 3 of 3)

225-2.4.22 RECIRCULATION SYSTEMS. The recirculation systems are of an even simpler type which are currently only installed on 1200 psi ships. These systems can be described as off-on type systems with a dead-band. In the RCC systems, the feedwater flow rate through each main feed pump is metered across an orifice with a differential pressure transmitter (Figure 225-2-14 and Figure 225-2-15). This transmitter delivers an output to a toggle relay or trip relay where it is compared to a mechanical setting which is the minimum permissible flow rate under which the pump can operate without recirculation. If the actual flow rate falls below this lower value, the trip relay or toggle relay will adjust its output in full range in order to open the RCC valve, providing minimum flow through the pump to protect it from overheating. Consult the applicable Naval Sea Systems Command (NAVSEA) technical manual for values to use in setting the differential pressures and recirculation rates. Again, these systems are essentially identical in operation regardless of their source of manufacture.

225-2.5 RESPONSIBILITIES OF SHIP’S FORCE

225-2.5.1 AUTOMATIC BOILER CONTROL SYSTEM CARE. The Engineering Officer shall be fully aware of the general condition of each ABC system, and the manner in which each is being operated and maintained. The Engineering Officer shall ensure by periodic Planned Maintenance System (PMS) performance by the ABC technicians that system integrity is not reduced and that proper maintenance is being performed by trained personnel only.

225-2.5.1.1 All unusual cases of component damage or system deterioration shall be reported to the Type Commander. The report shall state in detail the extent of damage or deterioration sustained and the causes, or at least the symptoms noted.

225-2.5.1.2 Under no circumstances may a control system component be exchanged for another type component, or a component calibration be altered from that data presently recorded in the ship's ABC system NAVSEA technical manual. Only Naval Surface Warfare Center, Carderock Division - Ship Systems Engineering Station (NSWCCD-SSES) can authorize change out of a component or modifying its calibration data. Any proposal to change without proper approval shall be declined by the Engineering Officer and reported to the Type Commander.

225-2.5.2 PERSONNEL REQUIREMENTS AND RESPONSIBILITIES. The senior Boiler Technician (BT) aboard ship is responsible for ensuring that the ship has at least two qualified console operators per space and at least two currently qualified maintenance technicians on-board. The senior BT win inform the Main Propulsion Assistant (MPA) officer of any personnel status change which would show this requirement deficient and request additional school billets to fill all vacancies.

225-2.5.2.1 The ABC technician aboard ship is responsible to perform all ABC system PMS, instruct all qualified console operators on proper use of the control system, and ensure that all components are operational. Any discrepancies shall be documented and reported to the senior BT who will then report to the MPA officer of the ship.

225-2.5.2.2 During all inspections, (Board of Inspection and Survey; Operational Propulsion Plant Examination and Light-Off Exam), the senior ABC technician shall be available to the ABC inspection boardmember but will not be required to demonstrate component (final control element) function. The actual component and plant operation is the responsibility of the space console operator and space personnel.

NOTE

If a problem arises (for example, a valve will not stroke) then the ABC technician is available to correct the problem at the discretion of the examining boardmember.

225-2.5.3 SHIP'S SUPPLY DEPARTMENT RESPONSIBILITY. It is the responsibility of the ship's supply department to ensure that the ship's Coordinated Shipboard Allowance List (COSAL) is up-to-date and that the allowance parts are available to the ship's ABC technicians. Any discrepancies in the COSAL shall be reported and corrected.

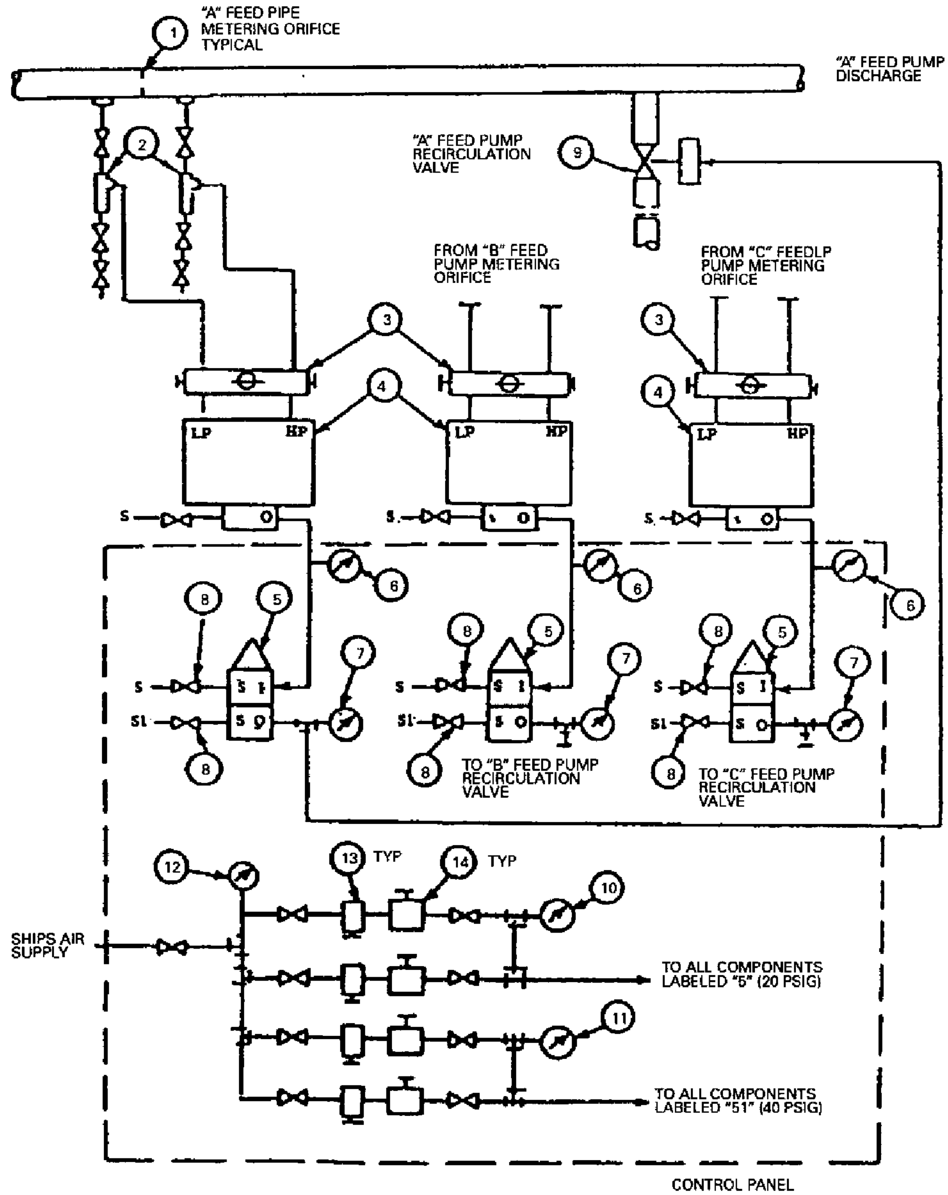
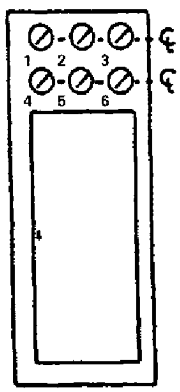


Figure 225-2-14 Schematic Diagram Main Feed Pump Recirculation Flow Control System (sheet 1 of 2)

LIST OF EQUIPMENT — QUANTITIES PER FIREROOM				
ITEM NO.	QTY	DWG/PART NO.	DESCRIPTION	REMARKS
1	3	D3022832A	ORIFICE, 5–INCH	BAILEY
2	6	4279 REV. C	SEDIMENT CHAMBER	NAVSSES
3	3	M1HC–3TF–SP	VALVE MANIFOLD	9C–4820–00–647–0715
4	3	D4R–13482B	DIFFERENTIAL PRESSURE TRANSMITTER	274A ITT BARTON
5	3	D–30694–01	TRIP RELAY	30694 GEN REG
6	3	1223U	RECEIVER GAUGE, 3–15 PSIG, 0–100 GPM	ASHCROFT
7	3	1223U	RECEIVER GAUGE, 0–60 PSIG, 3–1/2" DIAL	ASHCROFT
8	6	4M–4X–V4AR–8	ANGLE VALVE	PARKER–HANNIFIN
9	3	H7106397C–1	RECIRCULATION CONTROL VALVE, 1–1/2 INCH	YFFS–98, BAILEY
10	1		PRESSURE GAUGE, 0–30 PSIG	1H6685–00–246–2364
11	1		PRESSURE GAUGE, 0–100 PSIG	1H6685–00–244–1830
12	1		PRESSURE GAUGE, 0–200 PSIG	1H6685–00–527–6215
13	4	30282	AIR FILTER	30282 GEN REG
14	4	1824	AIR PRESSURE REGULATOR	40H50 MOORE

Figure 225-2-14 Schematic Diagram Main Feed Pump Recirculation Flow Control System (sheet 2 of 2)

LIST OF EQUIPMENT — QUANTITIES PER FIREROOM				
ITEM NO.	QTY	DWG/PART NO.	DESCRIPTION	REMARKS
1	3	538550	WATERFLOW TRANSMITTER	HAGAN 53N
2	3	N-556667	PNEUMATIC TOGGLE RELAY	HAGAN 58N
3	1	539561	PRESSURE REDUCING VALVE, 1/4 INCH	HAGAN
4	1	539561	PRESSURE REDUCING VALVE, 1/4 INCH	HAGAN
5	2	14298N	AIR FILTER, SELF-CLEANING STRAINER,1/4 INCH	LESLIE
6	1	539078-2	PRESSURE GAUGE, 0-100 PSIG 2 1/2 INCH DIA	U.S. GAUGE BU 2354E NSN 1H 6685-00-244-1830
7	4	539078-1	PRESSURE GAUGE, 0-60 PSIG 2 1/2 INCH DIA	U.S. GAUGE BU 2354 E NSN 1H6685-00-246-2365
8	3	540022	PNEUMATIC TRANSFER VALVE	VALVAIR
9	3	539079-7	PRESSURE GAUGE, 0-60 PSIG 0-100 PERCENT	U.S. GAUGE BU 1348 H
10	3	539079-14	PRESSURE GAUGE, 30-0 PSIG 0-100 PERCENT	U.S. GAUGE AU 1348 L
11	3	12429N 12434N	RECIRCULATING CONTROL VALVE	LESLIE DRNSL
12	3	541556	METERING ORIFICE	HAGAN



RECIRC VALVE POSITION INDICATORS

FEED PUMP FLOW INDICATORS

LEGEND

SERVICE	SYMBOL
GAUGE AND/OR IMPULSE LINES	
PNEUMATIC SIGNAL PRESSURE LINES	PN PN
COMPRESSED AIR SUPPLY	A
MAIN FEEDWATER LINES	

PANEL TAG WORDING

1 MN FEED PUMP A VALVE POSITION

2 MN FEED PUMP B VALVE POSITION

3 MN FEED PUMP C VALVE POSITION

4 MN FEED PUMP A

5 MN FEED PUMP B

6 MN FEED PUMP C

Figure 225-2-15 Hagan Schematic Diagram Main Feed Pump Recirculation Flow Control System (sheet 1 of 4)

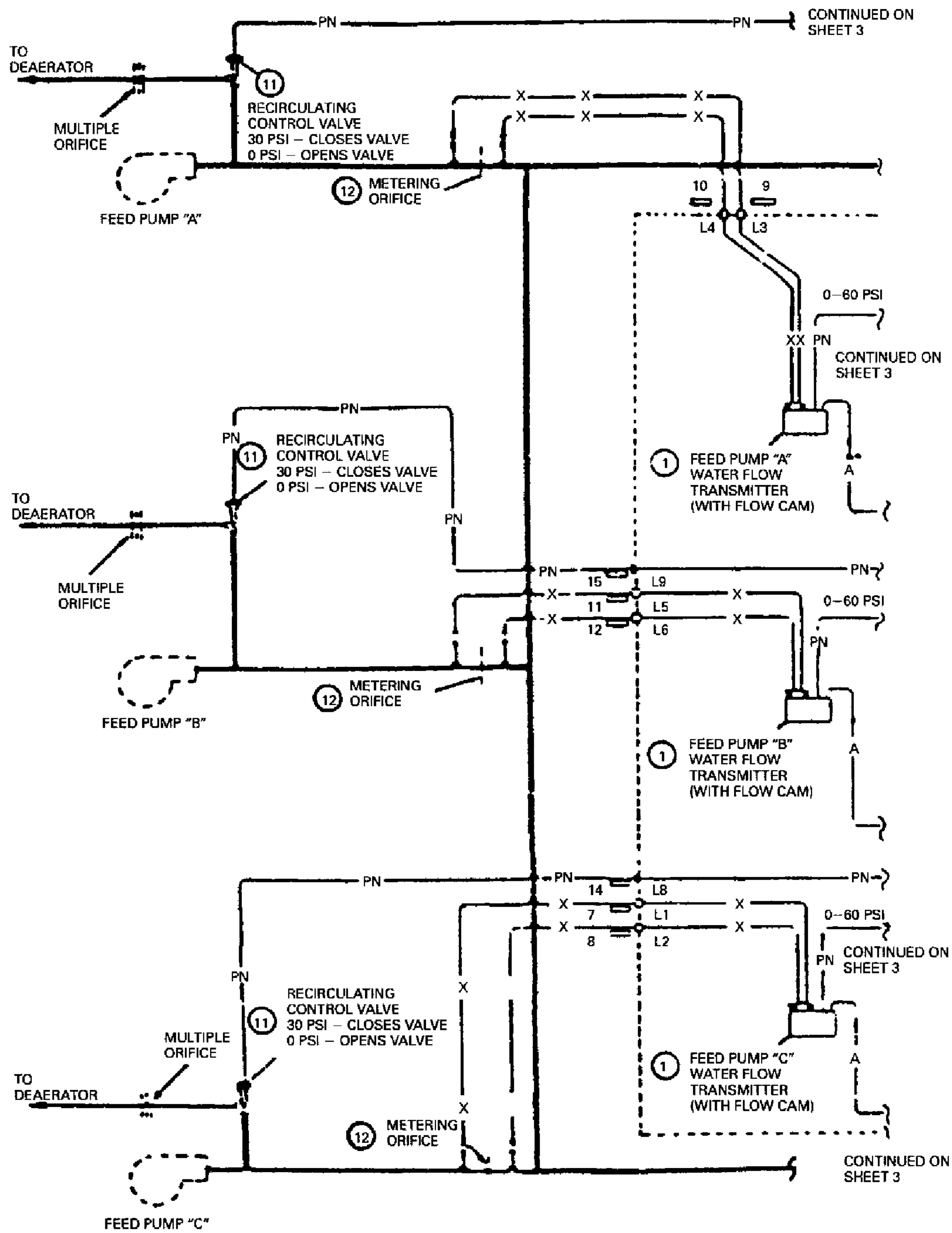


Figure 225-2-15 Hagan Schematic Diagram Main Feed Pump Recirculation Flow Control System (sheet 2 of 4)

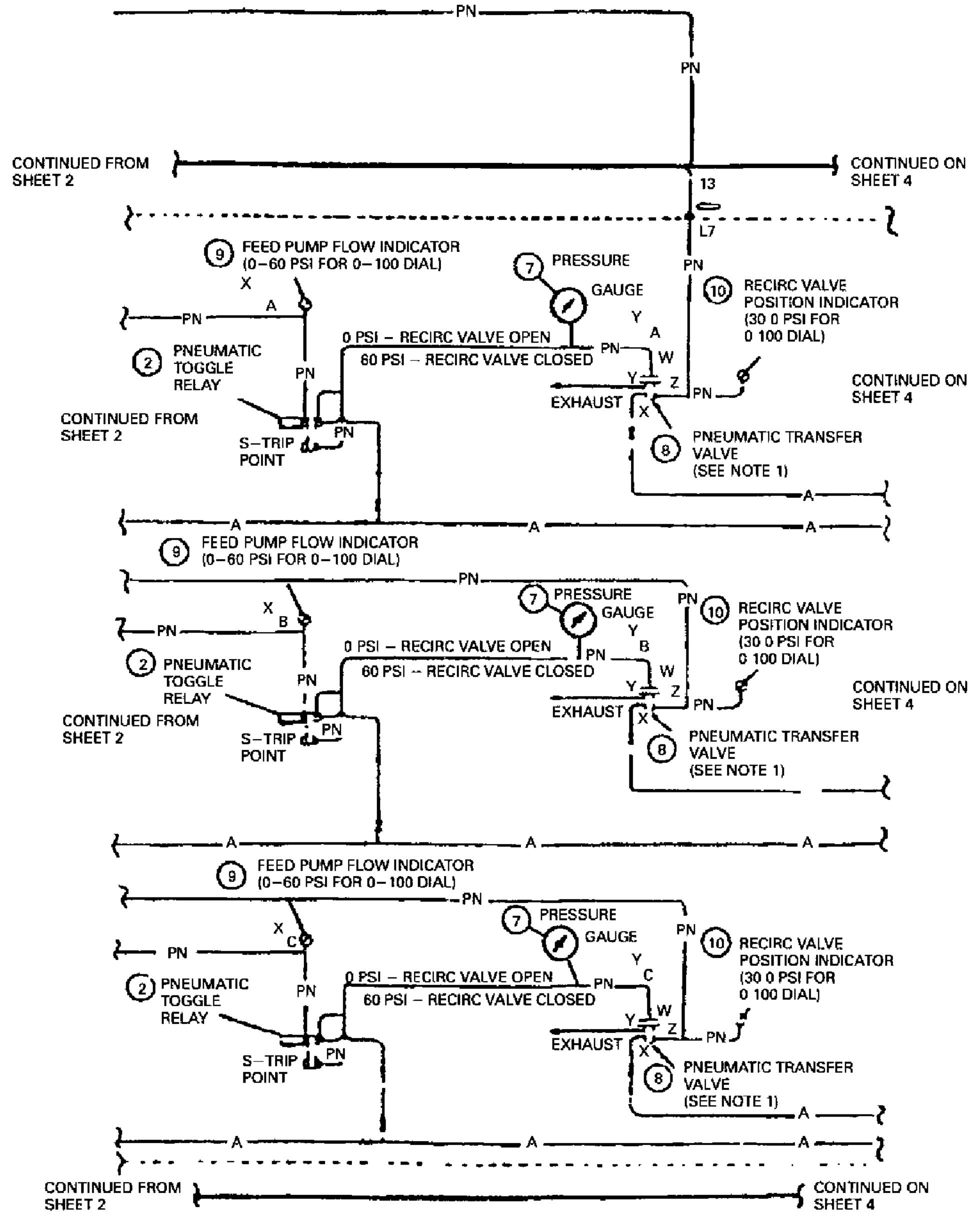


Figure 225-2-15 Hagan Schematic Diagram Main Feed Pump Recirculation Flow Control System (sheet 3 of 4)

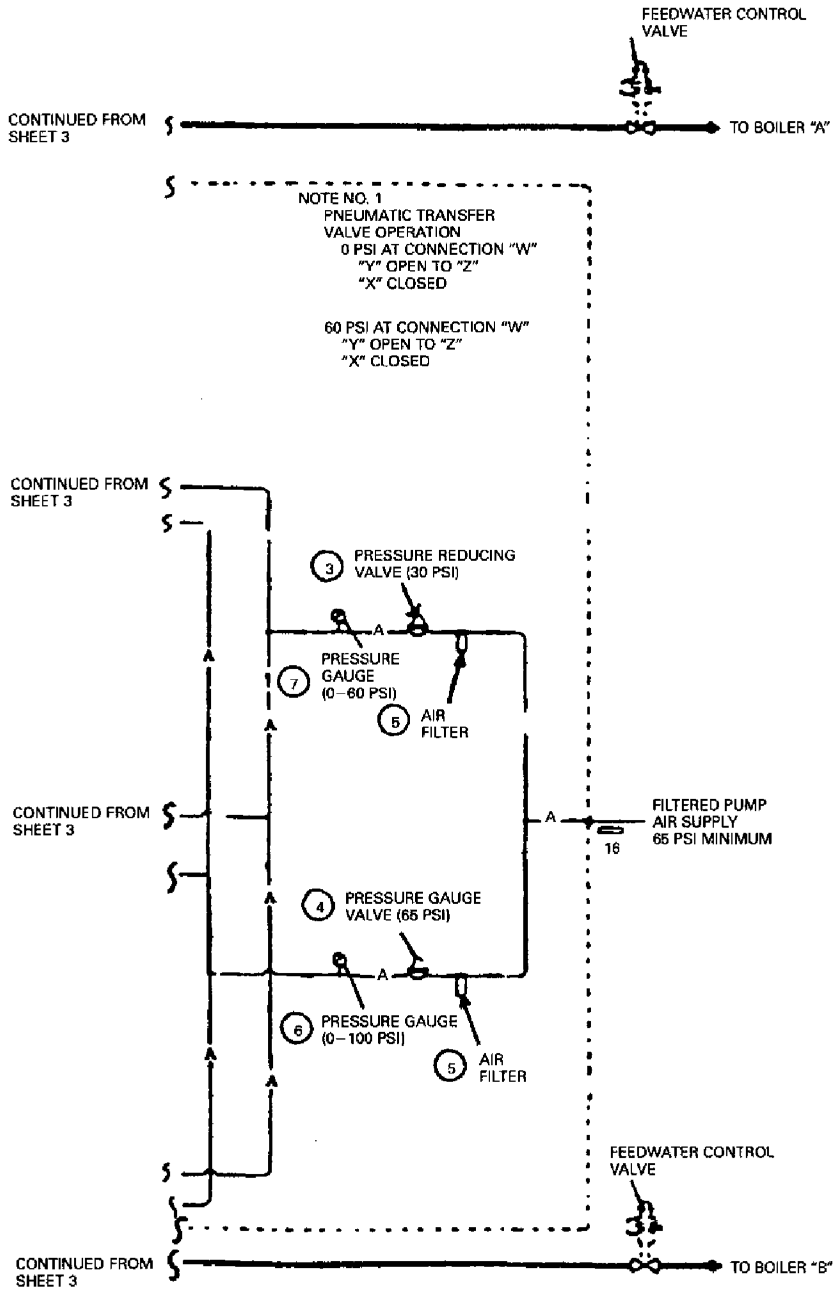


Figure 225-2-15 Hagan Schematic Diagram Main Feed Pump Recirculation Flow Control System (sheet 4 of 4)

225-2.5.4 OVERHAULING ACTIVITY RESPONSIBILITY. The overhauling activity shall be responsible to inspect all components to be overhauled, order correct parts and components, ensure proper system alignment, calibration, settings, and report to NSWCCD-SSES any unusual conditions found. These are to include piping sizes, orifices in pneumatic and sensing lines, missing components, additional cutout valves, and improper sensing line locations. All discrepancies should be documented by the overhauling activity with a copy to the ship involved, Type Commander, NSWCCD-SSES (Code 925) and Planning and Engineering for Repairs and Alterations (PERA).

225-2.5.5 INTERMEDIATE MAINTENANCE AS RESPONSIBILITY. Intermediate Maintenance Activities

(IMA's) will be responsible to inspect all components to be overhauled, correctly repair components, reinstall onboard ship, and ensure their proper hook-up. The Officer-In-Charge of each IMA or Shore Intermediate Maintenance Activity (SIMA) is responsible to the ship in ensuring that its components are being overhauled by a qualified ABC technician.

225-2.5.6 SHIP FORCE GENERAL GUIDELINES. Some of the general guidelines which should be followed by ship force are:

a. If the ship is accomplishing an authorized change or modification to the ABC system, the Engineering Officer shall report by way of message the nature of change. For example, component update by way of Ship Alteration (SHIPALT), and renewal of piping; identify component/piping involved including quantities and what boiler control systems are involved as well as personnel, for example, ship's force, private contractor, SIMA performing modifications and the completion dates. The message is to be addressed to NSWCCD-SSES (Code 925), PERA, and Type Commander.

b. Approved SHIPALT's accomplished during an overhaul period are currently reported by way of ship authorized work package listing at the beginning of such periods.

c. Any other authorized or unauthorized ship modifications/changes shall be documented and reported by way of message to NSWCCD-SSES (Code 925).

WARNING

Under no circumstance may a control system component be exchanged for another type component, or may a component calibration be altered from that data presently recorded in the ship's ABC system NAVSEA technical manual.

225-2.5.7 GENERAL DESIGN REQUIREMENTS. Due to the numerous individual components, piping systems, foundations, and accessibility requirements, the following data is a breakdown and listing of these requirements as they pertain to each section of the total ABC system:

a. Consoles and panel mounted equipment:
   1 Consoles and panels shall be secured to proper size foundation.
   2 Location of console and panel shall ensure accessibility for maintenance of components inside.
   3 Consoles and panels shall have drain holes in bottom panel. Any electrical connections inside console shall be covered and properly grounded to ensure no injury to personnel.
   4 No high-pressure gauge lines shall be located inside consoles or panels. Lines to gauges shall be external with gauge connections outside of enclosed areas.

b. Individual components mounted in engineering space:
   1 Steam flow, feed flow, and drum level transmitters shall be mounted with their bellows axis parallel to keel of ship and be located so they are accessible for maintenance. Access to internal damper adjustment shall be ensured.
   2 All components mounted in engineering space shall be located so that they are accessible for maintenance, not attached to boiler and not subject to heat, water, vibration, or dirt.

c. Air piping arrangements and supports:

1 Pneumatic supply air lines shall be 1/4 inch International Pipe Standard (IPS) copper MIL-T-24107 with silver brazed connections (MIL-F-1183), and all individual space mounted components except positioners to have 1/4 inch IPS UE/SB cutout valve located at the component and a reduced line size to 1/4 inch Outside Diameter (OD) copper (MIL-T-24107) downstream of each cut-out valve to the individual components with supply air connection at the component using 37 degree, flared tube fittings per MIL-F-18866.

2 Pneumatic output lines from all components (except positioners) shall be 1/4 inch OD copper (MIL-T-24107) using 37 degree, flared tube fittings per MIL-F-18866.

3 All positioner supply lines shall be 3/8 inch OD copper (MIL-T-24107) downstream of supply line 1/4 inch IPS UE/SB cutout valve to the positioner, and its output to the diaphragm actuator shall also be 3/8 inch OD copper (MIL-T-24107) with 37 degree, flared tube fittings per MIL-F-18866.

4 All pneumatic lines shall be properly braced and supported.

5 Whenever pipe thread connectors are used, teflon tape shall be used for the sealant (the teflon tape shall be tape version only per NSN 8030-00-889-3535; pipe dope or liquid teflon is not acceptable).

225-2.5.7.1 Teflon tape is considered a safe and effective sealant for tapered pipe joints in ABC systems, and its use is recommended. Any possible problems associated with its use can be virtually eliminated if the following procedures are utilized.

1. Apply teflon tape two threads back from the end of the fitting and wrap 1-1/2 turns around the fitting.
2. Wrap the tape in the direction of the thread spiral of the male thread to ensure that the tape does not unwrap as the fitting is tightened.
3. Under no circumstances should the tape extend beyond the first thread. This will prevent small pieces of the tape from entering components and fouling internal mechanisms.
4. Use tape with 1/4 inch width on pipe threads 1/8, 1/4, and 3/8 inch IPS. Use tape with 1/2 inch width on pipe threads 1/2 inch IPS and larger.
5. When a fitting wrapped with teflon is removed, thoroughly clean old teflon from the fitting and threaded connections before reinstalling.
6. Do not use teflon tape on any mechanical fitting such as flare, compression, or straight thread with metal or o-ring seals.

225-2.5.7.2 All transmitter sensing piping arrangements and material/fitting requirements shall be per NAVSSES drawing 4182.

225-2.5.7.3 All control system troubleshooting gauges shall be installed as shown on NAVSEA dwg:

a. 53711-221-5337283 - Automatic Combustion and Feedwater System (General Regulator)

b. 53711-221-5337284 - Automatic Combustion and Feedwater System (Hagan)

c. 53711-221-5467615 - Automatic Main Feed Pump Control System (Hagan)

d. 53711-221-5467616 - Automatic Main Feed Pump Control System (General Regulator).

225-2.5.7.4 Consoles located at the boiler firing aisle, where the console operator can easily view existing boiler gauges, need not have a separate gauge board as long as gauges mounted at boiler are according to MIL-B-18381.

225-2.5.7.5 A console located away from the boiler firing aisle, where the operator cannot view boiler firing aisle gauge board, will need a separate gauge board with duplicate gauges of those mounted at boiler front and shall also be according to MIL-B-18381.

225-2.5.7.6 The 8-1/2 inch dial pressure gauges used for controlled pressure indicator (superheater outlet, common steam header, and steam drum pressures) shall read the correct range and be shock resistant. For ships with setpoint at superheater outlet or common steam header, one 8-1/2 inch dial gauge shall be mounted at or near console, replacing existing full range gauges. For ships with setpoint at steam drum, one additional 9-1/2 inch dial gauge shall be mounted at or near console, replacing existing full range gauges. For ships with 1,200 psi steam systems, a suppressed range gauge is required. For ships with 600 psi steam systems, a 0 to 1,000 psi gauge is required. For 1,200 psi ships: 8-1/2 inch dial, suppressed range 1,000 to 1,500 psi, 5 psi increments, MIL-I-18997, NSN 668500-974-6513. For 600 psi ships: 8-1/2 inch dial, range 0 to 1,000 psi, 10 psi increments, MIL-I-18997, NSN 6685-00872-6345.

SECTION 3

OPERATION AND COMPONENT FUNCTIONS

225-3.1 INTRODUCTION

225-3.1.1 This section details the main objectives of the Automatic Boiler Control (ABC) system and describes its component level functions. The General Regulator and Hagan systems are discussed separately.

225-3.2 GENERAL REGULATOR AUTOMATIC BOILER CONTROL SYSTEM

225-3.2.1 GENERAL. The characteristics of a typical General Regulator ABC system are shown in Figure 225-2-10. There are two types of General Regulator ABC systems: series/parallel and inferential.

225-3.2.2 SERIES GENERAL REGULATOR AUTOMATIC BOILER CONTROL SYSTEM. On an increase in boiler load, the master demand signal is applied to the minimum signal selector relay as an increasing signal. The airflow feedback signal is also applied to the selector relay as an increasing signal that lags master demand due to blower inertia. The selector relay will select the lower of the two signals (airflow) as the fuel demand signal. Under this condition, the fuel demand signal will lag the master demand signal and the system is said to be in series.

225-3.2.3 PARALLEL GENERAL REGULATOR AUTOMATIC BOILER CONTROL SYSTEM. On a decrease in boiler load, the master demand signal decreases more rapidly than the airflow feedback signal due to blower inertia. The selector relay will select the lower of the two signals (master demand) as the fuel demand signal. Under this condition, the fuel demand signal matches the master demand signal and the system is said to be in parallel.

225-3.2.4 INFERENTIAL GENERAL REGULATOR AUTOMATIC BOILER CONTROL SYSTEM. The combustion control system measures a pressure differential across the burner opening (air register) and develops a pneumatic signal proportional to the rate of airflow per burner. Using this pneumatic signal, the system infers (or concludes from fact) that with this much airflow for combustion, only a given percent of fuel can be burned properly. Fuel flow is not measured in the system, but is inferred. Fuel flow is developed in relation to the combustion airflow per burner.

225-3.2.5 DESIRED STANDARD. The Automatic Combustion Control (ACC) system functions to maintain a constant setpoint. The setpoint will vary depending upon the point at which the measurement is taken and the size of the steam plant.

225-3.2.5.1 Setpoint for 1,200 psi Steam Plants. On the 1,200 psi steam plants, the setpoint is 1,275 psi if measured at the steam drum. The setpoint is 1,200 psi if measured from the superheater outlet or common header at all steaming rates.

225-3.2.5.2 Setpoint for 600 psi Steam Plants. On the 600 psi steam plants, the setpoint is 655 to 700 psi if measured at the steam drum. The setpoint is 600 to 615 psi if measured at the superheater outlet or common header at all steaming rates.

225-3.2.6 SUPPLY PRESSURE. Compressed air is required for operation of the pneumatic control components. S-1 supplies 18 to 20 psi. Compressed air is required for the operation of final control elements (characterizing relays and positioner air supply regulators). S-2 supplies 65 psi.

225-3.2.7 EFFECTIVE LOADING PRESSURE. The pneumatic signal between two items of pneumatic control equipment, except to the final control element, is 3 to 15 psi.

225-3.2.8 COMBUSTION CONTROL LOOPS AND COMPONENTS. The ACC system is made up of three different loops; demand, air, and fuel. Each loop controls a separate element and has several components. Each loop and its components are described in the following paragraphs.

225-3.2.8.1 Demand Loop Components. The demand loop consists of five components; steam pressure transmitter, maximum signal selector, steam pressure controller, high and low limit relays, and boiler AUTO/MAN control station. The purpose and principles of operation for each component are explained in the following paragraphs.

a. Steam pressure transmitter

    1 Purpose. Measures steam pressure at the steam drum, superheater outlet, or common header and develops a proportional pneumatic signal.

    2 Principle of operation.

        (a) The steam pressure transmitter usually measures 1,100 to 1,400 psi input with a 3 to 15 psi output loading pressure (1,200 psi steam plants), or measures 525 to 725 psi input with a 3 to 15 psi output loading pressure (600 psi steam plants).

        (b) Loading pressure when at desired setpoint (superheater 1,200 psi = 7.0 psi, drum 1,275 psi = 10.0 psi) is typically derived as follows

$$-1- LP = ((\text{setpoint minus minimum}) \times \frac{\text{load press range}}{\text{steam press range}}) + \text{min load press}$$

$$-2- LP = \frac{((1,200 - 1,100) \times 12)}{300} + 3$$

$$= 4+3 = 7 \text{ psi}$$

(c) As steam pressure input varies between 1,100 to 1,400 psi (1,200 psi steam plants) or 525 to 725 psi (600 psi steam plants) a proportional pneumatic signal varying between 3 to 15 psi is generated as output (input to steam pressure controller).

b. Maximum signal selector

1 Purpose. Selects the higher of two boiler steam pressure signals and sends it to the process chamber of the steam pressure controller.

2 Principle of operation. Two pneumatic signals are inputted with the greater signal seating internal seals allowing only the greater signal of the two input to output.

c. Steam pressure controller

1 Purpose.

(a) Receives a pneumatic signal proportional to steam pressure.

(b) Compares that signal with a setpoint pressure representing desired standard.

(c) Develops a demand signal to maintain boiler at desired standard for any boiler load.

2 Principle of operation.

(a) Introduce a setpoint signal which equals the desired value of steam drum pressure.

(b) Receive a pneumatic signal from the steam pressure transmitter termed the process signal.

(c) Compare the measured process signal to the introduced setpoint signal.

(1) If the measured process signal equals the introduced setpoint signal, no change occurs.

(2) If the measured process signal and the introduced setpoint signal are not equal, an error exists. Error is the difference between setpoint signal and process signal.

(d) Compute the amount and direction of the error. When an error exists, an immediate change proportional to the magnitude of the error occurs in the output of the controller due to proportional actions and the proportional band setting. Reset action causes the output of the controller to continue to change at a rate proportional to the error as long as the error exists.

(e) As the difference between the process signal and the setpoint approaches zero and balance is attained, reset action is slowed and finally ceases. The output of the controller remains constant at that new value which is necessary to maintain the process signal equal to setpoint signal.

d. High and low limit relays

1 Purpose. Prevent the master demand signal from bleeding out of range on the high-end or the low-end of the signal range operating pressure, respectively.

2 Principle of operation.

(a) Each relay receives an input that is transmitted as its output, unless that input falls outside the specified high or low value setting of the relay.

(b) The output of the highlimit relay is applied to the low-limit relay. The output of the low-limit relay is applied to the boiler control station as a demand signal and to the steam pressure controller as a feedback signal.

e. Boiler bias type Automatic/Manual (A/M) control station

1 Purpose. Enables the operator to select automatic or remote manual operation of the boiler control components. The ability to apply positive or negative bias to the master demand signal to balance boiler loads is also provided.

2 Principle of operation.

(a) If the A/M station is in the automatic mode of control the incoming signal will be reproduced 1:1 or with bias depending on the adjustment knob setting.

(b) If the A/M station is in the manual mode of control, the incoming signal will be dead-ended and a new signal will be generated and passed on the airflow controller and minimum signal selector. This mode of control for the ACC system is known as semiautomatic or one-knob control.

225-3.2.8.2 Air Loop Components. The air loop consists of eight components. The purpose and principles of operation for each component are explained in the following paragraphs.

a. Airflow transmitter

1 Purpose. Measures the pressure differential across the burner opening and develops a loading signal proportional to rate of airflow per burner.

2 Principle of operation.

(a) The airflow transmitter senses the pressure differential across the burner air registers and produces a pneumatic output signal that is proportional to the square root of that differential

(b) The output signal which is directly proportional to airflow per burner, is sent to the C chamber of the airflow controller by way of the fuel/air ratio relay as an airflow feedback signal and to the minimum signal selector. Example: Assume a boiler has four burners with all four air registers open. A 15 psi loading signal from the airflow transmitter would indicate 120 percent airflow; with only one air register open, a 15 psi loading signal would indicate 30 percent airflow.

b. Fuel/air ratio relay

1 Purpose. Provides the operator with the means to modify the airflow feedback signal as necessary to provide the proper fuel/air ratio needed to ensure optimum combustion throughout the firing range of the boiler.

2 Principle of operation.

(a) The ratio relay receives a pneumatic signal from the airflow transmitter.

(b) The input/output relationship of the relay is determined by adjusting the dial which positions a movable fulcrum on a beam.

(c) The ratio relay is also used for adding excess air to the boiler when soot blowing or during periods of improper system operation.

c. Airflow controller

1 Purpose. Develops a loading signal for the forced-draft blower speed control

2 Principle of operation.

(a) The airflow controller is a proportional-plus-reset controller which works on the same principle as the steam pressure controller (paragraph 225-3.2.8.1, step c), except it has a master demand signal instead of a setpoint signal

(b) If steam demand from the boiler is in a transient, an error will exist between the waster demand signal and the airflow feedback signal

(c) When an error signal exists, an immediate change in output proportional to the magnitude of the error will occur due to the proportional action of the controller. Reset action will cause the output of the controller to continue to change at a rate proportional to the rate of change of the error signal as long as the error exists.

(d) As the difference between the master demand signal and the airflow feedback signal approaches zero and balance is attained, reset action is slowed and finally ceases. The output of the controller will remain constant at the new value.

d. High and low limit relays. Perform the same function and in the same manner as described for the limit relays associated with the steam pressure controller (paragraph 225-3.2.8.1, step d.).

e. Steam now rate relay

1 Purpose. Provides positive rate action in the airflow loop based on changes in steam flow to speed up response of the forced-draft blowers, improving the response of both the airflow loop and fuel flow loop to changes in load.

2 Principle of operation.

(a) The steam flow rate relay is a proportional-only controller that repeats the airflow demand signal applied to the R chamber during steady-state conditions. During transients, the steam flow transmitter signal, applied directly to the C chamber and through a needle valve/volume chamber to the D chamber, modifies the output of the relay based on the time delay. When the C and D chambers eventually equalize, the output is once again equal to the airflow controller output signal.

(b) The output of the steam flow rate relay is applied to the forced-draft blower A/M control station.

f. Forced-draft blower master A/M control station. Some air loop systems do not have a blower master control station. Steam flow rate relay output goes directly to blower individual control stations in that case.

1 Purpose. Enables the operator to control forced-draft blower speed by manual means from one station or to allow the control system to control the blowers.

2 Principle of operation.

(a) If the A/M station is in automatic mode of control, the signal from the airflow controller will pass through unaffected.

(b) If the A/M station is in manual mode of control, the signal from the steam flow rate relay will be dead-ended, and a new signal will be manually generated and passed onto the individual blower control stations.

g. Forced-draft blower bias type A/M control stations

1 Purpose. Provide the operator with the means of controlling the speed of individual blowers by remote control or of placing the blowers under automatic control by way of the control system or one-knob control by way of the forced-draft blower master. The ability to apply positive or negative bias to the airflow demand input signal to ensure parallel operation is also provided.

2 Principle of operation.

(a) If the A/M station is in the automatic mode of control the incoming signal will be reproduced 1:1 or with bias depending on the adjustment knob setting.

(b) If the A/M station is in the manual mode of control, the incoming signal will be dead-ended, and a new signal will be manually generated and passed on to the forced-draft blowers, either increasing or decreasing their speed.

(c) The only time the forced-draft blower control stations would be in manual mode is during light-off, securing, or casualty control.

h. Forced-draft blower steam valve positioner or actuator

1 Purpose. Positions the forced-draft blower steam admission valve or turbine control valve to control blower speed in response to an input signal.

2 Principle of operation.

(a) Direct acting, pneumatic valve positioner on steam admission valve will load the actuator diaphragm until mechanical feedback signal satisfies input signal.

(b) Direct acting positioning relay and reversing relay load both sides of actuator cylinder which results in rotary motion of actuator arm. Mechanical linkage from actuator arm opens or closes turbine steam inlet valve.

225-3.2.8.3 Fuel Oil Loop Components. The fuel oil loop consists of four components. The purpose and principles of operation for each component are explained in the following paragraphs.

a. Minimum signal selector

1 Purpose. Maintains proper fuel/air ratio and fuel header pressure by preventing master demand signal from driving system during an up ramp and airflow feedback signal from driving system during a down ramp. The General Regulator model 50684 minimum signal selector relay is the signal selector used.

2 Principle of operation.

(a) Two internal diaphragms receive the two input signals. When signals are equal, internal vents are equally positioned, allowing output to equal these signals.

(b) When an imbalance in input signals occurs, the greater signal will close its internal vent. This will allow only the lower signal to output.

b. Fuel oil A/M control station

1 Purpose. Enables the operator to control fuel flow by manual means or to allow the control system to regulate fuel flow.

2 Principle of Operation.

(a) No bias capability.

(b) If the A/M station is in the automatic mode of control the signal from the minimum signal selector will pass through unaffected.

(c) If the A/M station is in the manual mode of control the signal from the minimum signal selector will be dead-ended. A new signal will be manually generated and passed on to the characterizing relay, increasing or decreasing fuel oil pressure.

(d) The only time the A/M station would be in the manual position is during light-off, securing, or casualty control.

c. Characterizing relay

1 Purpose.

(a) Receives a fuel demand signal which is linear to airflow.

(b) Converts this signal to a nonlinear signal which ensures the correct fuel pressure for every airflow rate.

(c) Ensures that fuel flow is linear to airflow.

2 Principle of operation.

(a) Fuel flow to the firebox is not metered. The system does not measure how many pounds per hour of fuel are being burned.

(b) The system will infer that for a certain fuel pressure, with specified sprayer plates, there will be a certain number of pounds per hour of fuel entering the firebox.

(c) The sprayer plate characteristics and valve gain are nonlinear and shall be compensated for. Also, the fuel oil control valve requires a loading pressure range different than the fuel flow demand signal range.

(d) The linear 3 to 15 psig fuel flow demand signal produces a fuel header pressure that will provide a fuel flow rate per burner that is proportional to airflow rate, thus ensuring optimum combustion at all boiler load conditions.

d. Fuel oil control valve

1 Purpose. Produces a certain fuel pressure at the burners in response to the control signal received and sets minimum fuel oil pressure.

2 Principle of operation.

(a) The valve receives a pneumatic signal from the characterizing relay and multiplies this signal by the valve gain to produce the fuel oil header pressure.

(b) The valve works on a force-balance principle, in that it requires the controlled oil pressure to be fed back internally to balance the incoming pneumatic control pressure.

(c) Minimum fuel oil pressure is set by adjusting the spring force in the valve with the external spring adjusting screw and locking it in place with a jamnut. Minimum fuel pressure adjustment is necessary to prevent flame loss at any burner due to insufficient fuel oil pressure at the burner tips.

225-3.2.9 THREE-ELEMENT FEEDWATER CONTROL SYSTEM COMPONENTS. The components of the three-element Feedwater Control (FWC) system are described in the following paragraphs and in Figure 225-2-10.

225-3.2.9.1 Drum Level Transmitter (Supervisor). Measures differential pressure in the steam drum and develops a pneumatic signal proportional to actual water level.

225-3.2.9.2 Steam Flow Transmitter (Demand). Measures differential pressure across a primary element in the steam line and develops a pneumatic signal proportional to steam flow.

225-3.2.9.3 Feed Flow Transmitter (Response). Measures differential pressure across a primary element in the feed line and develops a pneumatic signal proportional to feed flow.

225-3.2.9.4 Steam Flow/Feed Flow Differential Relay. Compares steam flow signal feed flow signal, and setpoint signal and develops a pneumatic output signal (demand) proportional to the difference between its inputs.

225-3.2.9.5 Setpoint Adjuster (Set at 9 psi). Generates a signal equal to the signal transmitted by the drum level transmitter at normal water level during steady-state steaming operation. This signal is applied to the steam flow/feed flow differential relay as a reference signal for relay operation.

225-3.2.9.6 Feedwater Flow Controller. Receives a demand signal from the steam flow/feed flow differential relay proportional to desired water level, compares it to a pneumatic signal proportional to actual water level (drum level transmitter output), and develops a loading signal (proportional-pl us-integral) for the FWC valve.

225-3.2.9.7 Feedwater A/M Control Station. Selects mode of control: manual or automatic.

225-3.2.9.8 Feedwater Control System Valve Positioner. Develops a loading pressure for the FWC valve that varies inversely with the feedwater demand signal. Mechanical feedback ensures precise positioning of the valve in response to changes in demand signal.

225-3.2.9.9 Feedwater Control Valve. Controls and maintains feedwater flow proportional to demand on the boiler. The valve closes with increasing loading pressure on the diaphragm to provide fail-open action when used with reverse-acting valve positioner.

225-3.2.10 THREE-ELEMENT FEEDWATER CONTROL SYSTEM OPERATING PRINCIPLES. The principles of operation of the three-element FWC system are described in the following paragraphs. Varying load conditions will cause the operating principles to change accordingly.

225-3.2.10.1 Steady Load Condition. Steam/feed flow signals to differential relay are equal. The output from the differential relay will be 9 psi, which is the setpoint signal to the feedwater flow controller. The output from the drum level transmitter with normal water level will be 9 psi to the feedwater flow controller. Any change in water level at a steady-load condition causes the controller to on-load or off-load to maintain water level at desired standard.

225-3.2.10.2 Increasing Load Condition. If boiler load is increased and steam flow is greater than feed flow, the output from the differential relay will be proportionally greater than setpoint. This will cause the feedwater flow controller to load on. But with the increase in boiler load, the water level in the steam drum will swell, increasing the output from the drum level transmitter, slowing down or stopping the action of the controller. Since the boiler is being underfed, water level will come back to normal and let the controller load on to match feed flow and steam flow. The drum level transmitter develops the supervisory signal which compensates for shrink and swell. The system will now react as at steady-load condition.

225-3.2.10.3 Decreasing Load Condition. If boiler load is decreased and steam flow is less than feed flow, the output from the differential relay will be proportionally less than setpoint. This will cause the feedwater flow controller to off-load, but with the decrease in boiler load, the water level in the steam drum will shrink, decreasing the output from the drum level transmitter, slowing down or stopping the action of the controller. Since the boiler is being overfed, water level will come back to normal and let the controller off-load to match feed flow and steam flow. The drum level transmitter develops the supervisory signal which compensates for shrink and swell. The system will now react as at steady-load condition.

225-3.2.11 FEED PUMP CONSTANT HEADER PRESSURE CONTROL SYSTEM COMPONENTS. The components of the feed pump constant header pressure control system are described in the following paragraphs; refer to Figure 225-2-12.

225-3.2.11.1 Feedwater Header Pressure Transmitter. A single, high-pressure transmitter is used to measure the feedwater pressure in the common header. A helical coil in the transmitter senses this pressure, and the amount of deflection of the coil determines the transmitter output signal. The transmitter output range is directly proportional to changes in header pressure.

225-3.2.11.2 Header Pressure Controller. The output of the header pressure transmitter is applied to the header pressure controller. The controller is a proportional-plus-reset controller that compares the process (feedwater header pressure) signal with an integral, springloaded adjustable setpoint. The pneumatic value of this setpoint reference is equal to that which the header pressure transmitter develops when header pressure is at setpoint. If no difference (or error) exists between the process signal and the integral setpoint, the controller output remains constant at that exact value which maintains equality between these two signals. If an error does exist, the controller generates an output change in the proper direction and to the extent necessary to restore header pressure to setpoint and balance these signals. When the feed pump(s) and control system have stabilized at the new demand, the controller maintains its output constant at the new value

a. The action of the controller in response to an error between its input and the integral setpoint is divided into two parts; proportional action and reset rate.

b. Proportional action is an immediate change in the controller output proportional to the magnitude of the error.

c. Reset rate causes the output of the controller to change at a rate proportional to the instantaneous value of the error, as long as it exists. As this error approaches zero and equilibrium is attained, the proportional component of the change in input disappears and the cumulative reset action ceases, leaving the controller output at the new balance state.

225-3.2.11.3 Automatic/Manual Control Station. The control station consists of an internal two-stage air pressure regulator with a manual adjustment knob, an internally ported valve body for distributing signal pressures, and a mounting panel that incorporates a duplex indicating gauge and control knobs. A two-position mode selector knob can be actuated to either MAN or AUTO to place the device being controlled by the station in either manual or automatic operation, respectively. The manual adjustment knob on the left-hand side of the panel regulates the pneumatic output signal of the control station generated by the internal air pressure regulator when in the manual mode of operation. The duplex gauge is a 3-1/2 inch diameter dial indicator scaled from 0 to 100 percent, corresponding to 3 to 15 psig minimum to maximum signal pressures. The input signal (automatic) is monitored by the center (black) pointer, and the control station internal air pressure regulator output (manual) is monitored on the peripheral (red) pointer. The control station output signal is shown on one of these indicators depending on the mode of operation. In automatic operation, the control station output is shown on the center (black) pointer, whereas in manual operation, the peripheral (red) pointer shows the control station output pressure.

225-3.2.11.4 Feed Pump Diaphragm Operator Positioner. The positioner is reverse acting with a standard bellows type pilot suitable for a 3 to 15 psig control range input. The operator positioner assembly consists of a steel case, housing the mechanical operating linkage, and a pneumatic pilot valve. A cover gasket is used to prevent dirt from entering the housing and impairing equipment operation.

225-3.2.11.4.1 The mechanical linkage in the positioner includes a turnbuckle assembly connected on one end to the control valve stem and on the other end to the travel adjustment lever assembly. This lever assembly consists of two steel levers that react to control valve position to depress the pilot range spring according to actual controlled valve position.

225-3.2.11.4.2 The valve positioner operates on the force-balance principle of operation. The spring loading force on the bellows assembly (which varies with the control valve stem motion and is therefore a measure of stem position) is balanced by the control (input) air pressure applied with the bellows assembly. A description of the operating principles of the pilot is described in the following paragraphs.

a. An increase in pressure forces the bellows assembly upward, opposing the spring loading indicative of valve stem position and decreasing the pilot opening to restrict supply airflow to the output port. As pressure to the valve actuator decreases, the actuator's diaphragm positions the valve stem.

b. The resultant motion of the valve stem, transmitted through the positioner lever assembly, compresses the positioner range spring opposing the loading force in the bellows. When the valve stem reaches the position called for by the control instrument, equilibrium is established between opposing forces, and the pilot valve stabilizes and holds the output pressure constant at the new value.

c. Operation of the positioner on a decrease in input signal pressure is similar to that described for an increasing input signal pressure except that all motions are reversed.

225-3.2.11.5 Feed Pump Diaphragm Operator. The feed pump diaphragm operator typically consists of a spring-loaded diaphragm enclosed in an upper and lower casing which are bolted together. A yoke is attached to the lower casing and enclosed in mechanical linkage which operates the valve. A positioner is mounted at the side of the yoke. The travel adjustment lever of the positioner is mechanically linked to the operator lever stem and operates with movement of the lever stem. Loading air pressure from the control system is applied to the positioner. Control air pressure from the positioner is applied to the top of the diaphragm, and there pressure is applied again at the tension of the diaphragm spring. When the pressure is great enough, the diaphragm moves downward against the spring tension, moves the operator stem downward, and opens the valve. With a decrease in control air pressure from the positioner, the spring pushes the diaphragm up, moves the operator stem up, and closes the valve. A handwheel is provided at the top of the diaphragm.

225-3.2.12 FEED PUMP CONSTANT HEADER PRESSURE CONTROL SYSTEM OPERATING PRINCIPLES. The principles of operation of the feed pump constant header pressure control system are described in the following paragraphs. Varying load conditions will cause the operating principles to change accordingly.

225-3.2.12.1 Steady-Load Condition. Under steady-load conditions, the control system maintains the speed of the feed pump(s) in operation so that the feedwater pressure in the common header is maintained at setpoint. The output of the feedwater pressure transmitter is such that it matches the integral setpoint of the feed pump pressure controller. The output of the controller is constant at that value required to maintain feed pump speed. The output of the pressure controller passes through the A/M control station to the feed pump diaphragm operator positioner.

225-3.2.12.2 Increasing Load Condition. When boiler load increases, feedwater demand increases. The FWC valve is positioned farther open to increase feedwater flow to the boiler. This results in a decreased pressure in the common feedwater header. The feedwater header pressure transmitter senses the pressure decrease and transmits a lower output signal to the feed pump header pressure controller. This causes the header pressure controller to generate an increased output signal that is proportional to the change in feedwater header pressure signal. This signal will continue to increase due to reset action until header pressure is restored to setpoint. This increased signal (feed pump demand signal) is applied through the feed pump A/M control station to the feed pump diaphragm operator positioner. The positioner decreases its output and positions the diaphragm operator to increase pump speed. The increasing pump speed increases feedwater flow and, therefore, increases feedwater pressure in the common header. As the header pressure increases, system response is reduced until the system is again balanced at the new feedwater flow rate with feedwater header pressure at setpoint.

225-3.2.12.3 Decreasing Load Condition. When boiler load decreases, feedwater demand decreases. The FWC valve is positioned farther closed to decrease feedwater flow to the boiler. This results in an increased pressure in the common feedwater header. The feedwater header pressure transmitter senses the pressure increase and transmits a higher output signal to the feed pump header pressure controller. This causes the header pressure controller to produce a decreased output signal that is proportional to the change in feedwater header pressure signal. This signal will continue to decrease due to reset action until header pressure is restored to setpoint. This decreased signal (feed pump demand signal) is applied through the feed pump A/M control station to the feed pump diaphragm operator positioner. The positioner increases its output and positions the diaphragm operator to decrease pump speed. The decreasing pump speed decreases feedwater flow and, therefore, decreases feedwater pressure in the common header. As the header pressure decreases, system response is reduced until the system is again balanced at the new feedwater flow rate with feedwater header pressure at setpoint.

225-3.2.13 FEED PUMP RECIRCULATION FLOW CONTROL SYSTEM COMPONENTS. The components of the feed pump recirculation flow control system are described in the following paragraphs and in Figure 225-2-14.

225-3.2.13.1 Differential Pressure Transmitter. The differential pressure transmitter measures the pressure drop across a metering orifice in the feedwater pipe between each feed pump discharge and the common feedwater header, and develops a pneumatic signal that is characteristic of the actual feedwater flow through the pipe. The transmitter unit consists of a stainless steel bellows with pulsation dampener for sensing differential pressure, and a pressure transmitter unit for developing a proportional output pressure. On an increase in feedwater flow through the metering orifice, differential pressure across the orifice increases, thereby resulting in an increased transmitter output. Conversely, on a decrease in feedwater flow, the transmitter output decreases accordingly.

225-3.2.13.2 Trip Relay. The trip relay is an on-off pneumatic switch that either blocks or passes a pneumatic loading signal to the recirculating valve diaphragm. Three inputs are received by the relay; the output of the differential pressure transmitter and supply air at 20 and 40 psig to the upper and lower supply air connections on the relay. Supply air at 20 psig, furnished to the upper relay connection, is used as a reference for comparison with the relay input signal from the differential pressure transmitter. The 40 psig supply air signal applied to the lower supply air connection is the signal that is either blocked or passes as the relay output depending on the relay position. On a decrease in feedwater flow below a predetermined value determined by the spring setting, the transmitter output signal decreases thereby closing the relay to block the 40 psig signal to the recirculating valve diaphragm. This pressure loss causes the recirculating valve to open allowing feedwater flow directly to the deaerating feed tank. As feedwater flow increases above a predetermined value determined by the needle valve setting, the transmitter output increases and the trip relay opens passing the 40 psig signal air pressure to the recirculating valve so that the recirculating valve closes. Normal minimum flow requirements are between 60 to 90 gallons per minute through a feed pump to prevent pump overheating.

225-3.2.13.3 Recirculating Control Valve. The recirculating valve is a diaphragm-operated valve of the air-to-close type. It is actuated by the output of the trip relay in the computing section of the control system. In the on state, the relay passes 40 psig air pressure to the diaphragm holding the valve in the closed position. On a decrease in feedwater flow, the trip relay blocks the air pressure to the diaphragm and vents the chamber to allow the valve to open.

225-3.2.14 FEED PUMP RECIRCULATION FLOW CONTROL SYSTEM OPERATING PRINCIPLES. The principles of operation of the feed pump recirculation flow control system are described in the following paragraphs.

225-3.2.14.1 Minimum Feedwater Flow. Recirculation will turn on when below minimum feedwater flow. When feedwater flow from the feed pump drops below a preset minimum value, the differential pressure transmitter senses the drop and transmits a decreased signal to the trip relay, which causes the relay to trip and shut off the air supply applied to the recirculating valve diaphragm and vents the diaphragm chamber so that the valve opens completely. The open valve recirculates feedwater directly from the feed pump to the deaerating feed tank maintaining a minimum flow through the feed pump, thereby preventing pump overheating.

225-3.2.14.2 Above Minimum Feedwater Flow. Recirculation will turn off when above minimum feedwater flow. When feedwater flow from the feed pump increases above a preset value, the differential pressure transmitter senses the increase and transmits an increased signal to the trip relay, which causes the relay to trip and open the air supply to the recirculating valve diaphragm, closing the valve. At feedwater flow rates above the preset minimum value, the flow through the pump is sufficient to cool the pump and feedwater recirculation is not necessary.

225-3.3 HAGAN AUTOMATIC BOILER CONTROL SYSTEM

225-3.3.1 GENERAL. The characteristics of a typical Hagan ABC system are shown in Figure 225-2-11. There are two types of Hagan ABC systems; series/parallel and inferential. The Hagan ABC system is described in the following paragraphs.

225-3.3.2 SERIES HAGAN AUTOMATIC BOILER CONTROL SYSTEM. On an increase in boiler load, the master demand signal is applied to the minimum signal selector relay as an increasing signal. The airflow feedback signal is also applied to the selector relay as an increasing signal that lags master demand due to blower inertia. The selector relay will select the lower of the two signals (airflow) as the fuel demand signal. Under this condition the fuel demand signal will lag the master demand signal and the system is said to be in series.

225-3.3.3 PARALLEL HAGAN AUTOMATIC BOILER CONTROL SYSTEM. On a decrease in boiler load, the master demand signal decreases more rapidly than the airflow feedback signal due to blower inertia. The selector relay will select the lower of the two signals (master demand) as the fuel demand signal. Under this condition the fuel demand signal matches the master demand signal, and the system is said to be in parallel.

225-3.3.4 INFERENTIAL HAGAN AUTOMATIC BOILER CONTROL SYSTEM. The Hagan combustion system measures a pressure differential across the burner opening (air register) and develops a pneumatic signal proportional to the rate of airflow per burner. Using this pneumatic signal, the system infers (or concludes from fact) that with this much airflow for combustion, only a given percent of fuel can be burned properly. Fuel flow is not measured in the system, but is inferred. Fuel flow is developed in relation to the airflow for combustion per burner.

225-3.3.5 DESIRED STANDARD. The ACC system functions to maintain a constant setpoint. The setpoint will vary depending upon the point at which the measurement is taken and the size of the steam plant.

225-3.3.5.1 Setpoint for 1,200 psi Steam Plants. On 1,200 psi steam plants, the setpoint is 1,275 psi if measured at the steam drum. The setpoint is 1,200 psi if measured from the superheater outlet or common header at all steaming rates.

225-3.3.5.2 Setpoint for 600 psi Steam Plants. On 600 psi steam plants, the setpoint is 655 psi if measured at the steam drum. The setpoint is 600 to 615 psi if measured at the superheater outlet or common header at all steaming rates.

225-3.3.6 SUPPLY PRESSURE. The Hagan ACC system utilizes a constant 65 psi supply air pressure.

225-3.3.7 EFFECTIVE LOADING PRESSURE. The ACC system develops an effective loading pressure from 0 to 60 psi.

225-3.3.8 COMBUSTION CONTROL LOOPS AND COMPONENTS. The ACC system is made up of three different loops; demand, air, and fuel. Each loop controls a separate element and has several components. Each loop and its components are described in the following paragraphs.

225-3.3.8.1 Demand Loop Components. The demand loop consists of four components: steam pressure transmitter, selector relay (Supermite 71H), steam pressure controller, boiler AUTO/MAN control station. The purpose and principles of operation for each component are explained in the following paragraphs.

a. Steam pressure transmitter

1 Purpose. Measures steam pressure at the steam drum, superheater outlet, or common header and develops a proportional pneumatic signal.

2 The steam pressure transmitter usually measures a 200 psi band (100 psi above setpoint and 100 psi below setpoint) with a 0 to 60 psi output loading pressure (1,200 psi steam plants), or measures a 60 psi band (30 psi above setpoint and 30 psi below setpoint) with a 0 to 60 psi output loading pressure (600 psi steam plants).

3 Principle of operation.

(a) Steam pressure is introduced to the metallic bellows.

(b) Upward force resulting from the steam pressure is transmitted through the bellows post to the beam.

(c) Tension on the spring pulls downward and opposes the upward force.

(d) The amount of tension on the loading spring determines the setting at which the unit begins to produce a pneumatic output.

(e) Beam movement is transmitted through the flexible connector and adjustment screw to the upper end of the escapement valve.

(f) Supply air at 65 psi is connected to the lower end of the escapement valve.

(g) Valve stem moves between inlet and exhaust seat.

(h) The relative positions of the valve stem and the two seats determine the opening of the inlet and exhaust ports and control the loading pressure.

(i) The change in pressure required to move the beam and escapement valve stem between zero and maximum loading pressure is termed proportional band (gain).

(1) The required gain is adjusted by means of the proportional band unit.

(2) The proportional band unit exerts a force downward on the beam opposing the tendency of the beam to move upward on an increase in header pressure.

b. Selector relay (Supermite 71H)

1 Purpose. Selects the higher of the pressure signals from the two boiler's steam pressure transmitters and sends it to the steam pressure controller.

2 Principle of operation.

(a) The Supermite 71H is used when the higher of two input signals is to be selected.

(b) In this application, the o-rings are placed in the two inner grooves on the spool.

(c) As either A or B input pressure rises, the o-ring on the side with less pressure will be forced against the circular port made by the casing and the spool, blocking that passage and allowing only the high-pressure input to pass out port C to the steam pressure controller.

c. Steam pressure controller.

1 Purpose.

(a) Receives a pneumatic signal proportional to steam pressure.

(b) Compares that signal with a setpoint spring force representing desired standard.

(c) Develops a demand signal to maintain boiler at desired firing rate for any boiler load.

2 Proportional-plus-reset action is built into the controller. The major parts are the following:

(a) Four pressure chambers with diaphragms

(b) Spring barrel on number 3 chamber

(c) Balance beam and posts

(d) Adjustable fulcrum

(e) Poppet or microlock valve

(f) Needle valve

(g) Volume tank.

3 Principle of operation.

(a) The output of the maximum signal selector is connected to the number 3 chamber where it is opposed by a spring force of 30 pounds, which represents setpoint steam pressure.

(b) When a difference exists between input and setpoint spring force, an immediate change in output proportional to the magnitude of the difference will occur due to proportional action.

(c) Reset action will cause the output of the controller to continue to change at a rate proportional to the difference between the input signal and setpoint as long as any difference exists. When the difference is eliminated, reset action ceases and the output of the controller is constant at a value necessary to provide air and fuel in the ratios required to maintain steam pressure at setpoint.

d. Boiler AUTO/MAN control station

1 Purpose. Allows operator to select automatic or remote manual operation of the boiler control components and allows operator to add or subtract bias to the system.

2 Principle of operation.

(a) When set for remote manual operation, this unit can be used as a remote manual means of positioning the final control elements.

(b) When set for automatic operation, the input signal passes directly through the transfer valve to the relay sender.

(c) The incoming signal is reproduced in the compensating relay and passes through the transfer valve to the final control element. It is also indicated on the manual indicator.

(d) Bias is introduced into the system by increasing or decreasing the spring force in the compensating relay. This will increase or decrease the pneumatic output signal from the relay.

(e) Positions of the transfer valve can be automatic or remote/manual reset. Reset is a position that shall be met before shifting to automatic or remote manual. When in reset, the output loading signal is locked out from the station to the next component. When in reset, the manual and automatic indicators shall be aligned before transferring to AUTO or MAN.

225-3.3.8.2 Air Loop Components. The air loop consists of eight components. The purpose and principles of operation for each component are explained in the following paragraphs.

a. Airflow transmitter

1 Purpose. Measures the pressure differential across the burner opening and develops a pneumatic signal proportional to rate of airflow per burner.

2 Principle of operation.

(a) The force applied at the measuring diaphragm is transmitted through the assembly as a force pushing downward on the beam.

(b) An escapement valve is located so that the stem follows the slightest movement of the beam.

(c) The output loading pressure from the escapement valve is connected to the balancing diaphragm.

(d) The balancing diaphragm opposes the force of the measuring diaphragm by pulling upwards.

(e) The two opposing forces are in balance when the value of the output loading pressure is proportional to the flow causing the pressure differential.

(f) Diaphragm movement is transmitted through the stem to the cam bar.

(g) The cam bar is forced to the right. The force of the cam pushes upward on the rollers attached to the bell crank rotating around a bearing point.

(h) The bell crank pulls upward on the loading spring which is connected to the beam.

b. Fuel/air ratio relay

1 Purpose. Provides the operator with the means for varying the fuel/air ratio in the combustion control system to ensure optimum combustion throughout the firing range of the boiler.

2 Additional uses are:

(a) To maintain clear stack when operating conditions result in less than optimum combustion.

(b) To provide positive combustion airflow when blowing tubes.

3 Principle of operation.

(a) The beam rests on an adjustable ball bearing fulcrum.

(b) When the fulcrum is located midway under the beam between the two diaphragms, the ratio will be 1:1 (50 percent). For ships equipped with one size sprayer plate capable of 120 percent boiler load (for example; VP Mod 10) normal ratio relay setting is 50 percent. For ships equipped with separate full power and overload plates, normal ratio setting can range between 52 to 57 percent.

(c) When the indicator is set below 50 percent, the output pressure will decrease.

(d) When the indicator is set above 50 percent, the output pressure will increase.

c. Airflow controller

1 Purpose. Controls speed of forced-draft blower(s).

2 Proportional-plus-reset action is built into the controller. The major parts are the following:

(a) Four pressure chambers with diaphragms

(b) Balanced beam and post

(c) Adjustable fulcrum

(d) Poppet or microlock valve

(e) Needle valve

(f) Volume tank.

3 Principle of operation.

(a) The output signal from the boiler A/M station is connected to number 2 chamber of the controller and represents a demand for airflow-per-burner.

(b) The output signal from the airflow transmitter fuel/air ratio relay is connected to number 3 chamber of the airflow controller.

(c) The two loading pressures exert a net force on the controller that is proportional to the difference between the master demand and the actual airflow.

(d) The controller transmits an output loading pressure which is the airflow demand signal.

(e) To complete the balance of forces in the controller, the loading pressure in chamber number 1 is balanced by connecting number 1 chamber with number 4 chamber through a needle valve and volume tank between the two chambers.

(f) This reset signal will cause the output of the controller to change at a rate proportional to the difference between the loading signals as long as any difference exists. When the difference returns to zero, reset action ceases and the output of the controller is constant.

d. Steam flow rate relay

1 Purpose. Improves response of blowers to sudden changes in steam flow.

2 Positive rate action is built into the relay. The major parts are the following:

(a) Four pressure chambers with diaphragms.

(b) Balanced beam and post.

(c) Adjustable fulcrum.

(d) Poppet or microlock valve.

(e) Needle valve.

(f) Volume tank.

3 Principle of operation.

(a) The output signal from the airflow controller is connected to number 4 chamber and is repeated as the Output signal under steady steaming conditions.

(b) The steam flow signal from the steam flow transmitter is connected to number 2 chamber and to number 3 chamber through a needle valve and volume tank.

(c) During steady steaming, the pressures in number 3 and number 2 chambers are equal and do not affect the output signal.

(d) When steam flow changes, the steam flow rate relay responds immediately to the change in pressure in chamber number 2. As steam flow stabilizes, the pressure in chamber number 3 approaches the pressure in chamber number 2 at a rate determined by the needle valve opening.

(e) The output loading signal is connected to the forced-draft blower master two-way A/M station.

e. Forced-draft blower control station

1 Purpose. Allows operator to select automatic or remote manual operation of forced-draft blowers.

2 No bias capability. The major parts are the following.

(a) Relay sender

(b) Two-way transfer valve

(c) Two indicators.

3 Principle of operation.

(a) The loading pressure from the airflow controller, transmitted through the steam flow rate relay, goes to the forced-draft blower control station and serves as the automatic loading signal.

(b) The loading pressure from the control station is connected to both forced-draft blower control stations.

(c) When the A/M station is set for automatic operation, the loading pressure from the steam flow rate relay passes directly through the transfer valve to the forced-draft blower A/M station. The value of this loading pressure is shown on the automatic signal indicator.

(d) When the A/M station is set for manual operation, the loading pressure from the steam flow rate relay is dead-ended, and a substitute loading pressure is established through manual adjustment of the handwheel of the relay sender. This value, known as the loading pressure, is shown on the manual signal indicator.

(e) The two indicators are a guide to the operator when using that station; all readings are in terms of percent of the maximum value.

f. Forced-draft blower signal range modifier (used on some systems)

1 Purpose. Modifies a signal to the forced-draft blower governor from 0 to 60 psi and 9 to 60 psi.

2 Principle of operation.

(a) This relay is a four chamber totalizer with a spring mounted on number 3 chamber.

(b) The spring force is adjusted to equal a 9 psi loading signal force so that the output of the totalizer is 9 psi when the signal from the forced-draft blower A/M station to chamber number 2 of the totalizer is 0 psi.

(c) The adjustable fulcrum is positioned to the left for a 0.85 gain, so that the output of the signal range modifier will be 60 psi when the input signal value is 60 psi.

(d) When properly adjusted, the signal to the forced-draft blower final control element will be 9 psi when the airflow controller output is zero, thus preventing Dead Band due to the forced-draft blower Woodward governor operating on a 9 to 60 psi signal range value.

g. Forced-draft blower A/M station

1 Purpose. Allows the operator to select automatic or remote manual operation of individual forced-draft blowers. Provides the operator with a means to add or subtract bias to parallel the forced-draft blowers.

2 Principle of operation.

(a) When set for remote manual operation, this unit can be used as a remote manual means of positioning the final control element.

(b) When set for automatic operation, the input signal passes directly through the transfer valve to the relay sender.

(c) The incoming signal is reproduced in the compensating relay and passes through the transfer valve to the final control element. It is also indicated on the manual indicator.

(d) Bias is introduced into the system by increasing or decreasing the spring force in the compensating relay. This will increase or decrease the output signal from the relay.

(e) Positions of the transfer valve can be automatic or remote/manual reset. Reset is a position that shall be met before shifting to automatic or remote manual. When in reset, the output loading signal is locked out from the station to the next component. When in reset, the manual and automatic indicators shall be aligned before transferring to AUTO or MAN.

h. Forced-draft blower Woodward governor

1 Purpose. Regulates blower speed in response to airflow demand signal.

2 Principle of operation.

(a) Speed setting mechanism receives pneumatic loading signal in 9 to 60 psig range.

(b) Speed setting pilot valve plunger, which is mechanically connected to input bellows, reacts to change the position of the speed setting servo piston.

(c) Servo piston movement changes compression of one speeder to establish a new governor speed setting. Servo piston movement also changes the restoring lever position to recenter the speed setting pilot valve plunger.

(d) The change in speeder spring compression causes the flyweights to move in or out changing the position of the pilot valve plunger with a resultant change in power cylinder position.

(e) The change in position of the power cylinder, which is connected by linkage to the steam inlet control valve of the blower turbine, causes blower speed to change.

(f) As blower speed changes, internal oil pressures recenter the pilot valve plunger and return the flyweights to the vertical position. After the pilot valve is centered the power cylinder stops at a position corresponding to the desired blower speed.

(g) If the oil pressures acting on the pilot valve plunger equalize at the same time and balance against the centrifugal force of the flyweights, the power cylinder will remain stationary and the blower will be operating at the desired speed.

225-3.3.8.3 Fuel Oil Loop Components. The fuel oil loop consists of four components. The purpose and the principles of operation for each component are explained in the following paragraphs.

a. Low signal selector/bias relay

1 Purpose. Selects the lower of two signals, the master demand signal or the airflow feedback signal as modified by the fuel/air ratio relay and bias relay. The bias relay adds between 0-4 psi to the ratio relay output. This relay improves steady state steam pressure stability. During boiler load increase, this selection ensures that fuel flow increase follows airflow increase, thus eliminating the tendency to smoke.

2 Principle of operation. Same as for the high signal selector (discussed in paragraph 225-3.3.8.1, step b.) except the o-rings are on the outside of the grooves.

b. Fuel oil A/M station (53N two-way transfer station)

1 Purpose. Selects mode of control to manual or automatic.

2 No bias capability. The major parts are the following:

(a) Relay sender

(a) Two-way transfer valve

(a) Two indicators.

3 Principle of operation is the same as for other two-way stations.

c. Characterizing relay

1 Purpose.

(a) Receives a fuel demand signal which is linear to airflow.

(b) Converts the signal to a nonlinear signal which ensures the correct fuel pressure for every airflow rate.

(c) Ensures that fuel flow is linear to airflow.

2 Principle of operation.

(a) Fuel flow to the firebox is not metered. The system does not measure how many pounds per hour of fuel is being burned.

(b) The system will infer that for a certain fuel pressure there will be a certain number of pounds per hour of fuel entering the firebox.

(c) The sprayer plate characteristics and valve gain are nonlinear and shall be compensated for. Also, the fuel oil valve requires a loading pressure range different than the fuel flow demand signal range.

(d) The linear 0 to 60 psig fuel flow demand signal thus produces a fuel oil header pressure that will provide a fuel flow rate per burner that is proportional to airflow rate, thus ensuring optimum combustion at all boiler load conditions.

d. Fuel oil control valve (G.R. Model 32028)

1 Purpose. Produces a certain fuel pressure at the burners in response to the control signal received and sets minimum fuel oil pressure.

2 Principle of operation.

(a) The valve receives a pneumatic signal from the characterizing relay and multiplies this signal by the valve gain to produce the fuel oil header pressure.

(b) The valve works on a force-balance principle in that it requires the controlled fuel pressure to be fed back internally to balance the incoming pneumatic control pressure.

(c) Minimum fuel oil pressure is set by adjusting the spring force in the valve with the external spring adjusting screw and locking it in place with a jamnut. Minimum fuel pressure adjustment is necessary to prevent flame loss at any burner due to insufficient fuel oil pressure at the burner tips.

225-3.3.9 THREE-ELEMENT FEEDWATER CONTROL SYSTEM COMPONENTS. The components of the three-element FWC are described in the following paragraphs and in Figure 225- 2-11.

225-3.3.9.1 Drum Level Transmitter (Supervisor). Measures differential pressure in the steam drum and develops a pneumatic signal proportional to actual water level.

225-3.3.9.2 Steam Flow Transmitter (Demand). Measures differential pressure across a primary element in the steam line and develops a pneumatic signal proportional to steam flow.

225-3.3.9.3 Feed Flow Transmitter (Response). Measures differential pressure across a primary element in the feed line and develops a pneumatic signal proportional to feed flow.

225-3.3.9.4 Steam Flow/Feed Flow Differential Relay. Compares steam flow signal, feed flow signal, and setpoint signal and develops a pneumatic output signal (demand) proportional to the difference between its inputs.

225-3.3.9.5 Feedwater Flow Controller. Receives a demand signal from the steam flow/feed flow differential relay proportional to desired water level, compares it to a pneumatic signal proportional to actual water level and develops a loading signal (proportional plus-integral) for the FWC valve.

225-3.3.9.6 Feedwater A/M Control Station. Selects mode of control: manual or automatic.

225-3.3.9.7 Feedwater Control System Valve Positioner. Develops a loading pressure for the FWC valve that varies inversely with the feedwater demand signal. Mechanical feedback ensures precise positioning of the valve in response to changes in demand signal.

225-3.3.9.8 Feedwater Control Valve. Controls and maintains feedwater flow proportional to demand on the boiler. The valve closes with increasing loading pressure in the diaphragm to provide fail-open action when used with reverse acting valve positioner.

225-3.3.10 THREE-ELEMENT FEEDWATER CONTROL SYSTEM OPERATING PRINCIPLES. The principles of operation of the three-element FWC system are described in the following paragraphs and in Figure 225-2-11. Varying load conditions will cause the operating principles to change accordingly.

225-3.3.10.1 Steady-Load Condition. Steam/feed flow signals to differential relay are equal. The output from the differential relay will be 30 psi, which is the setpoint signal to number Z chamber of the controller. The output from the drum level transmitter with normal water level will be 30 psi to number 3 chamber of the feedwater flow controller. Any change in water level at a steady-load condition causes the controller to on-load or off-load to maintain water level at desired standard.

225-3.3.10.2 Increasing Load Condition. If boiler load is increased and steam flow is greater than feed flow, the output from the differential relay will be proportionally greater than setpoint. This will cause the feedwater flow controller to load on. But with the increase in boiler load, the water level in the steam drum will swell, increasing the output from the drum level transmitter, slowing down or stopping the action of the controller. Since the boiler is being underfed, water level will come back to normal and let the controller load on to match feed flow and steam flow. The drum level transmitter develops the supervisory signal which compensates for shrink and swell. The system will now react as at steady-load condition.

225-3.3.10.3 Decreasing Load Condition. If boiler load is decreased and steam flow is less than feed flow, the output from the differential relay will be proportionally less than setpoint. This will cause the feedwater flow controller to off-load, but with the decrease in boiler load, the water level in the steam drum will shrink, decreasing the output from the drum level transmitter, slowing down or stopping the action of the controller. Since the boiler is being overfed, water level will come back to normal and let the controller offload to match feed flow and steam flow. The drum level transmitter develops the supervisory signal which compensates for shrink and swell. The system will now react as at steady-load condition.

225-3.3.11 FEEDWATER HEADER PRESSURE CONTROL SYSTEM. The components of the feedwater header pressure control system are described in the following paragraphs; refer to Figure 225-2-13. Pressure control is achieved through the header pressure controller and the signal range modifier. Feedwater header pressure is applied to the controller, which develops an output signal varying between minimum and maximum. The output signal is transmitted to the signal range modifier, which modifies the controller's output signal to match the characteristics of the governor valve operator of the feed pump turbine. The output of the signal range modifier (demand signal) is fed through the main feed pump A/M control station to the receiving bellows of the governor valve operator.

225-3.3.12 FEEDWATER HEADER PRESSURE CONTROL SYSTEM OPERATING PRINCIPLES. Feedwater header pressure is applied to the bellows of the header pressure controller by way of a manifold. The actual header pressure is compared to a spring force representing a desired header pressure (setpoint). Proportional-plus-reset action is applied to any error which may exist to develop an output signal. This demand signal, as altered by the signal range modifier, will regulate feed pump speed to restore and maintain feedwater header pressure at a value equal to setpoint. When feedwater header pressure deviates from setpoint, an immediate change directly proportional to the magnitude of the deviation occurs in the controller output. This change is fed back to the reset bellows by way of a needle valve and volume chamber. This causes the controller output to continue to change at a rate proportional to the instantaneous values of the deviation, as long as any difference exists between the desired and actual header pressure.

225-3.3.12.1 Feedwater Header Pressure Controller. The controller operates on a force-balance principle and incorporates proportional-plus-reset control action. The controller compares actual header pressure introduced into a measuring bellows with a loading spring which represents desired feedwater header pressure. An output loading pressure is developed by way of an escapement valve, and is fed through tubing to the proportional band bellows and reset bellows by way of a needle valve. Anytime there is an error between spring force and actual header pressure, the output will change at the same proportion as the error. Output loading pressure received by the proportional band bellows opposes the measured pressure bellows. Deviation from desired header pressure is determined by the position of the proportional band bellows and is termed proportional band. Output loading pressure, received by the reset bellows by way of the reset needle valve, resets the controller and reduces the amount of proportional band at a delayed rate. The response of the reset bellows is determined by setting of the needle valve.

225-3.3.12.2 Signal Range Modifier. The signal range modifier is used to create an output signal whose range differs from its input to be compatible with the characteristics of the pneumatic bellows in the governor valve operator, which controls the speed of the feed pump turbine. The range modifier receives an input signal from the header pressure controller into chamber 2 and produces an output signal in chamber 1. The ratio of input to output is adjustable by changing the location of the fulcrum assembly on the beam.

225-3.3.12.3 Main Feed Pump Auto/Manual Control Station. The console mounted control and transfer stations are assembled and piped up, and each station consists of the following components:

a. Two 2-1/2-inch receiver gauges. The upper gauge indicates the automatic signal, and the lower gauge indicates the manual signal. Both indicators read 0 to 100 percent and are inverse signal indicating gauges (at 0 percent signal, output equals 60 psi).
b. One transfer valve. The valve directs the pneumatic signal received by the feed pump governor actuator when in automatic, or blocks the signal to enable a manually generated signal to be transmitted to the governor actuator when in manual.
c. One reverse acting 53N relay sender. The relay sender enables the operator to generate a desired signal in order to control pump speed. Clockwise rotation of the handwheel causes a decrease in the output signal which increases pump speed when in manual control. The transfer valve, when set on automatic, allows the signal from the range modifier to pass through the transfer valve to the air lock valve and air lock vent valve to the governor actuator of the feed pump turbine. When the transfer valve is set for manual operation, the output from the range modifier is interrupted at the transfer valve, and a substitute signal is generated by adjustment of the manual signal generator, associated with the transfer valve to the air lock valve and air lock vent valve to the governor actuator of the feed pump turbine.

225-3.3.13 RECIRCULATION CONTROL LOOP COMPONENTS. Component descriptions are given in the following paragraphs to further explain the principles of operation of the recirculation control loop. Each pump has its own system (Figure 225-2-15).

225-3.3.13.1 Metering Orifice. An orifice is welded in the feed pump discharge increaser fitting with pressure taps provided upstream and downstream of the orifice plate. The pressure drop across the orifice, when measured and processed by the recirculation control loop, provides the signal for actuation of the recirculation control valve.

225-3.3.13.2 Feedwater Flow Transmitter. The feedwater flow transmitter is designed to detect the pressure difference across the feedwater flow metering orifice and convert that difference into a pneumatic signal which is directly proportional to the rate of feedwater flow. This is accomplished by applying the high-pressure impulse to one side of the pressure chamber and the low pressure to the other side. The differential tends to rotate the beam. Force from the balancing diaphragm opposes this tendency. When these two forces are in equilibrium, the output signal is proportional to the flow causing that differential. Any change in pressure differential tends to rotate the beam and move the valve stem to a new position decreasing or increasing the transmitted output pressure to a level which will again cause the forces to balance.

225-3.3.13.3 Pneumatic Toggle Relay. The output signal from the waterflow transmitter is connected to chamber 4 of the toggle relay. A spring barrel is attached to that chamber and opposes the pneumatic force from the transmitter. The spring tension is adjustable and its setting determines the feedwater flow rate at which the relay will trip and transmit an output signal to the pneumatic transfer valve. This output is also piped to chamber Z and acts to reinforce the torque created by the input signal. The distance of the fulcrum assembly from chamber 4 determines the value at which the relay will reset. This value equates with the gallons per minute differential between trip and reset.

225-3.3.13.4 Three-Way Pneumatic Transfer Valve. The transfer valve is a three-way diaphragm operated valve which receives its pressure signal from the toggle relay. Air pressure, imposed on a diaphragm, forces the piston and valve stem downward, opening port X to port Z, and closing Y. This allows maximum air supply to pass to the recirculation valve, thereby closing it. With zero pressure on the diaphragm, port X is closed, and port Y is open to Z. This vents the air signal in the line to the recirculating valve, allowing the valve to open.

225-3.3.13.5 Recirculation Control Valve. This diaphragm control valve is a direct-acting, spring-loaded (spring acting against the air loaded diaphragm), needle plug, valve-above-seat type with renewable stellited seat inserts, and self-aligning guides. The body and bonnet are cast steel and the superstructure is cast aluminum material. With maximum pressure on the diaphragm, the valve is closed to the deaerating feed tank and total feedwater flow is provided to the boiler. With the signal vented, the valve is open and feedwater flow is through the multiple orifice (a flow restrictive device) to the deaerating feed tank.

225-3.3.14 RECIRCULATION CONTROL LOOP OPERATING PRINCIPLES. As indicated on the recirculation control system diagram (Figure 225-2-15), waterflow is metered across an orifice in the discharge line by a waterflow transmitter. This transmitter delivers a variable output (minimum to maximum) to the pneumatic toggle relay which utilizes the variable signal to trip its output. The output signal from the toggle relay is fed to the three-way pneumatic transfer valve, which passes a regulated air pressure directed to the diaphragm of the recirculation control valve. The recirculation control loop automatically recirculates feedwater flow from the feed pump discharge to the deaerating feed tank when the flow through any feed pump decreases below a preset value (Figure 225-2-15). This feature is necessary to prevent overheating and possible pump damage if the pump were allowed to operate at low flow rates for an extended period of time. The recirculation control loop consists of the components discussed in the following paragraphs.

225-3.3.14.1 Feed Flow Transmitter. The feed flow transmitter is a differential measuring device that senses a pressure drop across a metering orifice inserted in the feed pump discharge fitting, and develops an output signal representing pump flow. The output to the feed flow signal and is applied to chamber 4 of the toggling relay.

225-3.3.14.2 Toggling Relay. A toggling relay converts the variable signal received from the feed flow transmitter to a signal which will be constant at either 0 or 60 psig, and will open or close the recirculation control valve. When input is at the predetermined minimum or below, the output signal is minimum which opens the recirculation valve.

When the input signal increases above a preset value, the toggle relay has a pneumatic maximum output signal which closes the recirculation valve.

225-3.3.14.3 Three-Way Pneumatic Transfer Valve. A three-way pneumatic transfer valve receives a loading signal from the toggling relay. If the signal is minimum, the valve vents the line to the recirculating control valve, closes the valve port from the reducing valve, and vents all pressure from the recirculation valve diaphragm causing the valve to open. If the signal from the pneumatic toggling relay is maximum, the vent port is closed and the output of the reducing valve is ported through the valve to the recirculating valve diaphragm, closing the recirculation control valve.

225-3.4 PNEUMATIC AIR SUPPLY SYSTEMS

225-3.4.1 GENERAL. The air supply for the ABC system consists of line filters, pressure regulators, associated piping and valving, and pressure gauges. Pressurized air is supplied by a dedicated control system compressor at 100 to 120 psig. Ship's service air system is usually piped into the supply system for emergency service. (See Figure 225-2-10 and Figure 225-2-11.)

NOTE

Some ships utilize ship's service air as their normal ABC system supply air. Refer to individual ship technical manual for specific ship variations.

225-3.4.2 AUTOMATIC BOILER CONTROL SYSTEM SUPPLY AIR REQUIREMENTS. The following paragraphs describe the requirements necessary to provide high quality air to the ABC system.

a. Clean, moisture-free, and oil-free air should be provided for dependable component operation.

b. Air receivers and in-line moisture separators should be blown down at least once per watch.

c. Supply system dehydrators should be used, if available, to remove access system moisture.

d. Air pressure from the control air receiver is usually 100 psig and is then reduced downstream to the various working air pressures of the control system.

e. In-line filters of the cotton impregnated type are also used.
   1 These filters should be replaced as outlined in the specific ship Planned Maintenance System (PMS).
   2 When renewing these filters, all filters should not be renewed at once. Lint in the new filters could carry through and could clog system components.

225-3.4.3 AUTOMATIC BOILER CONTROL SYSTEM SUPPLY AIR COMPONENTS. Individual ship's ABC system supply tubing layouts vary. Consult Section 7 of this chapter or individual ship technical manual for details.

WARNING

Shutting off the air supply to a single component will render that component inoperative. This could have serious consequences on the system operation. When preparing to take a component out-of-service, it is necessary to transfer the control system to remote, manual, or local manual operation.

225-3.5 AIR LOCK SYSTEM

225-3.5.1 GENERAL. An air lock system is provided to lock the setting of the forced-draft blowers, fuel oil valves, feedwater control valves, and main feed pump final control elements at values existing at the instant of supply air failure. As a result, these variables are held constant until the control air supply has been restored and the air lock system is reset for normal operation, or until the final control element in each system is transferred to local manual operation. An air lock system is shown in Figure 225-3-1.

225-3.5.2 AIR LOCK SYSTEM DESCRIPTION. An air lock system is provided to lock the setting of the forced-draft blower, fuel oil and feedwater final control elements to maintain airflow, fuel flow and feedwater flow at values existing at the instant of supply air failure. As a result, these flows are held constant until the control air supply has been restored and the air lock system is reset for normal operation, or until the boilers are transferred to local manual operation. A typical air lock system is shown in Figure 225-3-1. The unregulated air supply services the master trip valve, connection D, to hold it in the open position. The output pressure of the master trip valve is equal to the supply pressure as long as the outlet pressure exceeds the setting of the spring adjusting screw on top of the master trip valve. The master trip valve spring is set for a trip value of 65 psig. A pressure reducing valve is installed upstream of the master trip valve, and downstream of the reset valve, to reduce the unregulated air supply to 80 psig. The use of this valve ensures that the air lock valve diaphragms do not fail due to over-pressurization.

225-3.5.3 AIR LOCK SYSTEM OPERATION. The operation of the air lock system is described in the following paragraphs.

a. In the event the air supply fails and pressure falls below the trip value (65 psig), the spring force of the master trip valve exceeds the diaphragm force due to reduced pressure at connection D. The master trip valve closes and exhausts the individual air lock valve D connections back through A-C of the master trip valve. This triggers the individual air lock valves to close, blocking the control signal to the final control elements. Combustion and feedwater control systems continue to operate at rates existing at the instant of trip. The individual air lock trip valves are adjusted to trip at 40 psig.

b. After air failure has occurred, combustion, feedwater, and feed pump control should be transferred to local manual operation and preparations made to resume normal operation when the air supply is restored.

c. The air lock header pressure remains at zero until the air lock system is reset. The air lock system cannot be reset until the unregulated air supply pressure is in excess of the trip value (65 psig).

d. To reset the air lock system, the air lock vent valves of the fuel oil valve, forced-draft blower steam valve actuators, single acting forced-draft blower vane actuators, feedwater control valves, and main feed pump valve actuator shall be turned to the VENT position. Double acting forced-draft blower vane actuator(s) air lock(s) are left in the BYPASS position. Then the air lock reset valve button is depressed and held in position. The available air pressure and the air lock pressures are indicated by pressure gauges at the air lock panel station. The reset valve button should be released when air lock pressure exceeds the master trip valve setpoint. The master trip valve and individual air lock valve trip points shall be maintained at 65 and 40 psig, respectively.

e. Once air lock header pressure is restored, forced-draft blower steam valve actuators, feedwater control valve, and main feed pump valve actuators air lock vent valves are returned to BYPASS position and system is returned to remote manual control and then to full automatic control using ship's engineering operational sequencing system procedures.

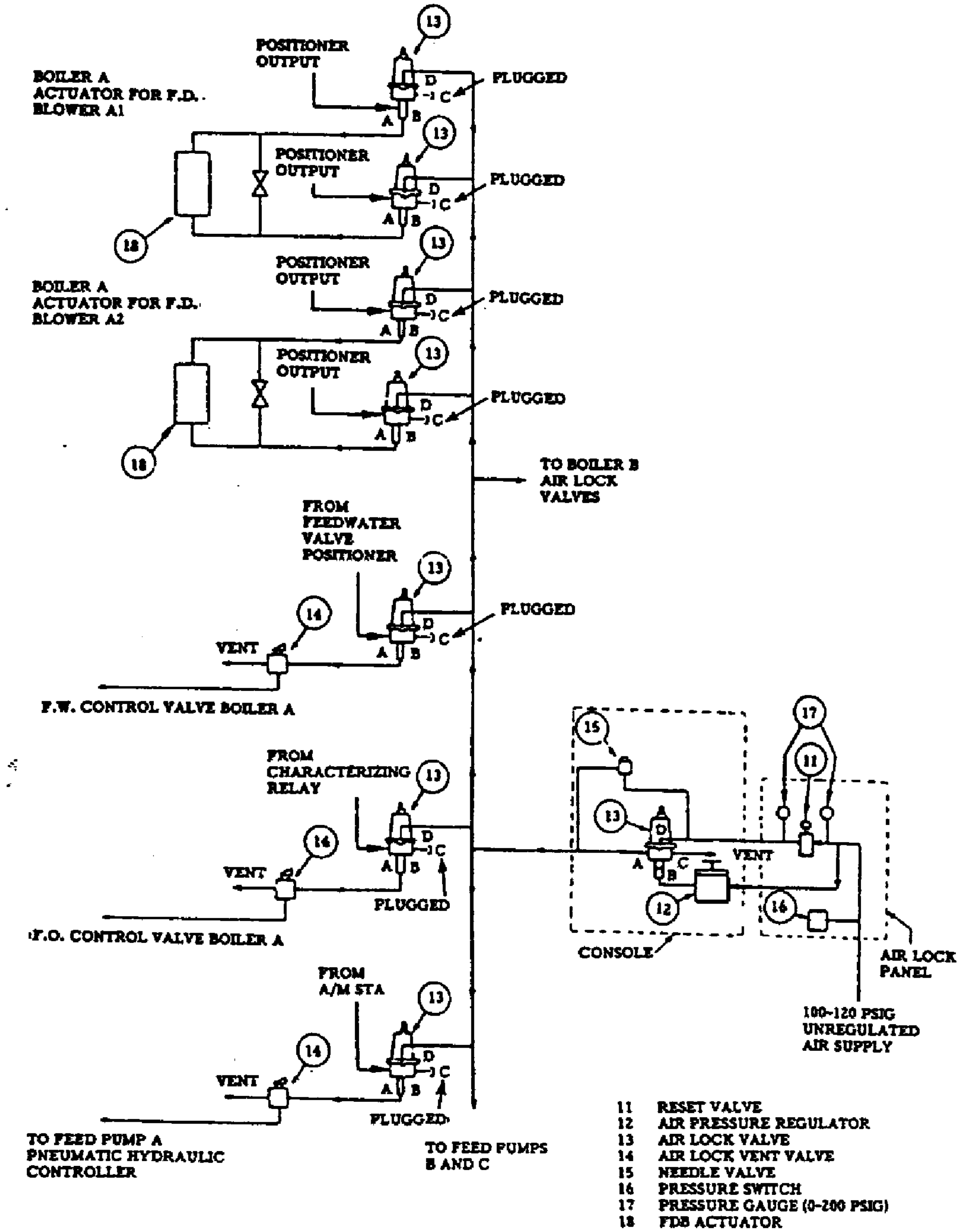


Figure 225-3-1 Air Lock System

SECTION 4

ON-LINE VERIFICATION AND TROUBLESHOOTING

225-4.1 INTRODUCTION

225-4.1.1 On-Line Verification (OLV) procedures were developed to provide each ship with a systematic approach to Automatic Combustion Control (ACC), Feedwater Control (FWC), and Feed Pump Control (FPC) system alignment, maintenance, and troubleshooting. They are intended to be used by the ship's Boiler Technician (ET) responsible for ACC/FWC/FPC system maintenance under the direction of the ship's Engineering Officer. OLV procedures are contained in a serialized manual pertinent to a particular ship/class or have been incorporated as volume II of the ship's Naval Sea Systems Command (NAVSEA) Automatic Boiler Control (ABC) system technical manuals.

225-4.1.2 OLV provides ship's force a means of keeping the systems aligned and maintained properly without the need for outside assistance. Using the procedures, the ship can quantitatively check control system performance (while the system is on-line and operating) and determine which component or components need adjustment or repair. The procedures have been proven aboard ship, both at sea and during in-port steaming periods, and they have been demonstrated to be an effective way for a BT to align, maintain, and troubleshoot the ABC and FPC systems. Experience has demonstrated that on those ships where the OLV procedures are used, system performance and reliability have improved and Casualty Reports (CASREP's) have been reduced.

225-4.1.3 Training for ship's personnel in the use of the OLV procedures is provided in the 7 or 8 week ABC/FPC maintenance courses conducted at the Fleet Training Centers. If necessary, on-site training conducted by NSWCCD-SSES/FTSCLANT/FTSCPAC can be arranged through the ship's TYCOM.

225-4.2 ON-LINE VERIFICATION CONCEPT

225-4.2.1 GENERAL. The objective of proper alignment and maintenance of ACC, FWC, and FPC systems is to achieve satisfactory overall control system performance. Overall system performance is measured by using the boiler flexibility test or flex test. The purpose of the flex test is to verify that the ABC and FPC systems are installed, working, and correctly calibrated to maintain steam pressure, water level, and combustion conditions within specification requirements during both steady-state and transient steaming conditions. Simply failing the flex test does not provide the BT with enough information to troubleshoot the system and to determine why the test failed. More detailed system testing information is needed, since malfunction or misalignment of almost any component in any of the control loops can cause failure of the flex test.

225-4.2.2 PROCEDURE. The OLV provides a set of checks that quantitatively verifies proper performance of each of the subsystems or control loops within the ACC, FWC, and FPC systems. Passing all of the checks ensures that the controls will give satisfactory overall system performance. The controls should then pass the flex test. If they do not, the fault lies outside the control systems, or the flex test was not conducted properly.

225-4.2.3 TROUBLESHOOTING. The OLV also provides troubleshooting guides for determining which component or components need adjustment or repair when a check fails or when system performance is not satisfactory.

225-4.2.4 REFERENCE CHECK RESULTS. The OLV checks, both static and dynamic, systematically test the performance of the controls against established acceptance criteria or standards. The standards are called the reference check results and are contained in the reference data table of the ship's OLV procedure manual. By periodically checking to ensure that the systems' controls meet these standards (within tolerances specified in individual check procedures), satisfactory control system performance is ensured.

225-4.2.5 REFERENCE COMPONENT ALIGNMENT SETTINGS. As a part of the initial OLV procedure implementation, the final settings of the various controllers and relays in the control systems are recorded and entered in the ship's OLV procedures as the reference component alignment settings. These are the settings (proportional band, gain, and reset adjustment settings, bleed valve openings, and so forth) on the various components that produce the reference check results.

225-4.2.5.1 There is an important distinction between the reference alignment settings and the reference static and dynamic check results. While the reference check results do not change, the reference alignment settings may change slightly over time. If a system component is replaced at some time after procedure implementation, the new device may have to be set at a slightly different setting than the old one to achieve the same performance (meet the reference check result) in an on-line check.

225-4.2.5.2 A component may also become worn with use and eventually require a slight adjustment of its settings to meet the check criteria.

225-4.2.6 TROUBLESHOOTING AND ALIGNMENT. Troubleshooting and supplementary alignment procedures are included in the OLV procedures. When a check is failed, the check procedures indicate the appropriate corrective action. In most cases, the BT is directed to a troubleshooting chart or fault-logic chart. The chart provides instructions for systematically locating the component or components which caused failure of the check. If the suspected component requires realignment, the chart will direct the BT to the appropriate alignment procedure which may appear on the chart itself, in the control system technical manual, or in supplementary alignment procedures also contained in the OLV procedures. The supplementary alignment procedures specify limits on how far a setting can be adjusted to achieve the reference performance. If the component cannot be adjusted to produce the proper check result with a setting within the specified range, appropriate corrective action is indicated (for example, replacement of a defective component or component part).

225-4.2.6.1 As indicated in the preceding paragraph, the reference component alignment setting listing provides a record of what the settings shall be in order to obtain the reference check results. If a setting is inadvertently changed or if a new component is installed to replace a damaged one, the reference setting provides a starting point for checking out the component using the appropriate check procedure. Where the troubleshooting guides or the supplementary alignment procedures direct a change in a component setting, the OLV procedures instruct the technician to update the reference setting in the reference data table.

225-4.2.6.2 In ships where OLV has been implemented, the OLV procedures are incorporated into the Planned Maintenance System (PMS). Maintenance Requirement Cards (MRC's) for the ABC and FPC systems refer the BT to specific OLV data sheets contained in the ship's OLV procedures manual. Management information such as personnel and time requirements are also shown on the MRC's.

225-4.3 ON-LINE VERIFICATION PROCEDURES

225-4.3.1 GENERAL. The OLV procedures include the following:

a. OLV check procedures
b. Static check procedures
c. Dynamic check procedures
d. Guidelines for running periodic flex tests
e. Troubleshooting procedures

f. Supplementary alignment procedures

g. Reference data.

225-4.3.2 ON-LINE VERIFICATION CHECK PROCEDURES. The OLV check procedures are provided as data sheets in the OLV procedures. The data sheets give step-by-step instructions for running the check procedures and provide spaces for recording the check data (gauge readings, component settings, and so forth). The check procedures are of two types, static and dynamic.

225-4.3.2.1 Static Check Procedures. Static check procedures are tests which check control system performance in the steady-state, that is, with boiler load steady and the system settled out. The static checks monitor not only the controlled process (for example, steam pressure or drum water level), but also many of the component input and output signals to make sure they bear the right relationship to each other. The procedures are run using the data sheets included in the OLV procedures. The static checks include:

a. Low Power ACC/FWC Static Check. In this check, the steady-state performance of the system is checked out at low power with burner fuel oil pressure near, but above, its minimum value.

b. High Power ACC/FWC Static Check. This check is almost identical to the low power ACC/FWC static check that it is conducted at steady-state high power, at a power level at or near the upper end of a flex test (85 to 95 percent of boiler full power).

c. Feed Pump Speed Control Low Power Static Check (applicable to ships with pneumatic FPC only). This check can be run at the same time the low power ACC/FWC static check is made, and confirms satisfactory low power performance of the FPC.

d. Feed Pump Speed Control High Power Static Check (applicable to ships with pneumatic FPC only). This check is identical to the low power FPC static check and can be run when the high power ACC/FWC static check is made.

e. Steam Pressure Transmitter Static Check. This procedure checks the Steam Pressure Transmitter (SPT) calibration by manually raising and lowering controlled steam pressure and checking SPT output. The check is run at a moderate boiler loading.

f. Drum Level Transmitter Static Check. This procedure checks the Drum Level Transmitter (DLT) calibration by manually raising and lowering the actual boiler water level and checking DLT output. There is no restriction on power level for this check. However, it is best to run it in port.

g. Steam Flow/Feedwater Flow Differential Relay Static Check (General Regulator systems only). This test checks the proportional action of the differential relay. With the FWC and forced-draft blowers in remote manual, the air supply to the steam flow transmitter is secured, then restored. Relay response to turning on the transmitter is measured. This check is run at a low to moderate steaming level.

h. Fuel/Air Ratio On-Line Check. This procedure provides an on-line check of the fuel/air ratio and the ACC components that control fuel/air ratio. Fuel/air ratio is adjusted and stack condition and fuel oil loading are observed at both mid and high power levels.

225-4.3.2.2 Dynamic Check Procedures. The dynamic check procedures test how well the controls respond to changes in plant conditions. However, all of these checks are run with the plant steady-steaming. A change is introduced in most cases either by securing or opening the air supply to a component or by making a fast, controlled input signal change. Like the static checks, the dynamic checks are run using data sheets provided in the OLV procedures. The dynamic checks are:

a. Steam Pressure Controller Dynamic Check. This test checks the proportional and reset action of the Steam Pressure Controller (SPC). In addition, on General Regulator systems, it checks the settings of the high and low limit relays. With the control system in the remote manual mode, steam pressure is changed and controller response is measured. The check is run at a moderate boiler loading.

b. Airflow Control Dynamic Check. This test checks the proportional and reset action of the airflow controller and overall airflow control loop performance during a change in airflow demand. Demand is changed by changing boiler auto/manual control station loading. On General Regulator systems, this check also tests the settings of the high and low limit relays. The check is run with the blowers slightly above their minimum speed.

c. Steam Flow Rate Relay Dynamic Check (not applicable to ships with electric motor-driven forced-draft blowers). This test checks the rate action of the steam flow rate relay (SFRR). With the FWC and forced draft blowers in remote manual, the air supply to the steam flow transmitter is secured, then restored. SFRR response to turning on the transmitter is measured. The check is run at a moderate boiler loading.

d. Feedwater Flow Controller Dynamic Check. This test checks the proportional and reset action of the Feedwater Flow Controller (FFC). On General Regulator systems with FWC in remote manual the proportional action is checked by increasing the setpoint adjuster output and measuring FFC response. Then, with the FWC still in remote manual, selected component air supplies are secured and then restored to check controller reset action. On Hagan systems, the entire check is conducted by securing component air supplies and making a quick change in FWC station loading to check controller action. The check should normally be run pierside, but can be run while underway as long as FWC station loading is within the range specified in the data sheet.

NOTE

The previous paragraphs are representative of a typical list of static and dynamic checks. Other checks may be included in some ship's OLV procedures in order to check a particular component unique to the type of control system installed in that ship. Consult specific ship technical manual for variations.

225-4.3.3 OFF-LINE MAINTENANCE REQUIREMENTS. The OLV procedures emphasize maintaining the systems on-line as much as possible. Routinely checking the systems with the static and dynamic check procedures eliminates the need for component removal and disassembly for maintenance. However, some off-line preventive maintenance is still required. These requirements are listed in the applicable MIP for ABC systems.

225-4.3.4 BOILER FLEXIBILITY TEST PROCEDURE PURPOSE. The flex test has a twofold purpose. It will ensure the shipboard boiler ACC and FWC systems are correctly installed and adjusted to maintain boiler steam pressure, water level, and combustion conditions within specification requirements during both steady-state and transient conditions. The flex test is also used to obtain reference data suitable for verifying continued satisfactory performance of boiler ACC and FWC systems.

225-4.3.4.1 Troubleshooting Procedures. Each of the static and dynamic checks lists its acceptance criteria, that is the reference check results. If all of the acceptance criteria for a check are met, then the system passes that check. If any one of the criteria is not met, the check is failed and the procedure data sheet for that check indicates what corrective action should be taken. The procedure may direct the control system technician to perform some specific maintenance, or it may direct use of a troubleshooting chart. The troubleshooting charts are included in the OLV procedures and are in the form of logic charts. The charts lead the technician through the troubleshooting process by telling which checks should be made or what other actions should be taken, and by asking specific questions to determine where in the system the problem lies. The various logic symbols used in the troubleshooting charts are explained at the beginning of the troubleshooting chart section of the OLV procedure.

225-4.3.4.2 The troubleshooting procedures in the OLV procedures do not cover all possible system problems. The technical manuals for the control systems and components also contain troubleshooting information. When a problem arises that is not covered by the OLV procedures, look to the technical manuals for additional instructions.

225-4.3.4.3 The troubleshooting charts are to be used as directed when a check is not passed. However, they may also be used whenever a problem turns up in operation of the controls. The titles of the charts are descriptive of system problems and can be used to determine what chart or charts to use. However, the first action that shall be taken when a problem occurs is to place the boiler in a safe operating condition. The troubleshooting procedures should be applied only after such action is taken.

225-4.3.5 SUPPLEMENTARY ALIGNMENT PROCEDURES. When a component misalignment is detected while running a check procedure or following a troubleshooting chart, the control system technician may be directed to a Supplementary Alignment Procedure (SAP) for the component. These SAP's are contained in the OLV procedures. They supersede the alignment procedures given in the system technical manual for the specific components covered. The SAP's cover in detail such settings as the proportional band or gain and reset rate of a controller. In most cases, however, they do not cover certain other adjustments such as the zero and tracking adjustments of a General Regulator controller or adjustment of the poppet valve on a Hagan totalizer. Refer to the system technical manual for instructions concerning these other adjustments, and for instructions on disassembly or repair of the components.

225-4.3.6 REFERENCE DATA. This section of the OLV procedures contains the following:

a. Desired check results
b. Component alignment settings
c. Reference graphs
d. Component calibration data.

225-4.3.7 FLEX TEST REQUIREMENTS. These requirements meet Level I criterion. See PMS card for Level II, III, and IV limits. The following steps are required for flex test:

a. Main boilers and their associated control systems shall meet the following performance requirements during up and down ramp load changes of 70 percent boiler full power in 45 seconds, within a range from 15 to 95 percent of boiler full power.
    1 For systems with steam pressure controlled at the superheater outlet or at a point in a common header, the maximum allowable steam drum pressure deviation is:
        (a) Minus 6 percent of the steam drum pressure measured at the instant of the start of the transient load increase.
        (b) Plus 2 percent of the steam drum pressure measured at the instant of the start of the transient load decrease.

2 For systems with steam pressure controlled at the steam drum, the maximum allowable steam drum pressure deviation is:

(a) Minus 8 percent of the normal steam drum operating pressure for an increasing load change.

(b) Plus 3 percent of the normal steam drum operating pressure for a decreasing load change (except LHA/LHD class which is plus four percent of the normal steam drum operating pressure for a decreasing load change).

3 Steam drum water level shall not deviate more than plus or minus 4 inches from normal water level as measured in the boiler gauge glass unless otherwise specified in PMS card for boiler flex test.

b. Load changes shall be accomplished under a smokeless condition as determined by the visual smoke periscope, without manually lighting or securing burners, and using normal underway sprayer plates.

c. Forced-draft blowers are not required to be in parallel during ramp load changes.

d. Following completion of a 70 percent ramp load change in 45 seconds in either direction, conditions shall stabilize within the limits for steady-state as specified in the following step, in not more than 4 minutes from the start of the load change.

e. During steady-state steaming at either the upper or lower load level controlled steam pressure shall be maintained within plus or minus 5 psi of setpoint, drum water level shall be maintained within plus or minus 1 inch of normal and the forced-draft blowers shall be parallel within 300 rpm. Stability shall be observed over a period of at least 2 minutes. Stability is defined as that operating condition under which controlled steam pressure and controlled drum water level are maintained within plus or minus 5 psi and plus or minus 1 inch, respectively, and the forced-draft blowers are parallel within 300 rpm.

f. Flex tests shall be accomplished with boiler control systems in the full automatic mode, that is, control is to be accomplished completely without human assistance. Manual adjustment of the control systems during load change and steady-state tests will invalidate the flex test. At both upper and lower load conditions, blower bias shall be limited such that the difference between any two forced-draft blower control stations output signals is no greater than 6 percent.

225-4.3.8 PRETEST CONDITIONS. The following machinery plant conditions shall be established for the flex tests:

a. All interacting systems such as forced-draft blowers and governors, main feed pumps and associated controls, auxiliary exhaust system, fuel oil pump pressure regulators, and fuel oil burners shall be operating properly.

b. In the event that both initial and final flex test loads cannot be attained with one boiler in operation, a second boiler may be placed on-line. When two boilers are in operation in the machinery space, the boiler to be tested shall be in full automatic control and the other boiler shall be adjusted to the firing rate necessary to maintain the steaming rate required to establish the desired initial (low end) steaming rate on the boiler to be tested; this firing rate should then be maintained throughout the flex tests which follow.

c. There shall be sufficient fire-room auxiliary equipment on the line to support the 100 percent single boiler steaming rate.

d. The test boiler shall have all burners in service using normal underway sprayer plates. The fuel/air ratio relay may be adjusted for optimum combustion efficiency (+/- 3 marks for General Regulator and +/- 6% for Hagan Systems), but shall not be adjusted during ramp changes. For ships equipped with a burner management system that automatically lights and secures burners in response to load changes, all burners shall be available for use by the burner management system. During the tests, the burners shall be allowed to light and secure automatically without manual intervention.

e. All automatic controls in the machinery space (except for the idle boiler combustion control system and the automatic (programmed) throttle control system (APS), if installed), shall be in the automatic mode.

f. Before conducting boiler flex tests, it shall be determined that forced-draft blowers are parallel to within 300 rpm under steady-state steaming conditions at both the upper and lower boiler load conditions.

g. Visual smoke indicators shall be in good working condition and free of soot or dirt on optical surfaces.

h. Calibration of the following gauges that are to be used in the tests is current:

   1 Boiler superheater outlet pressure

   2 Boiler steam drum pressure

   3 Common header pressure

   4 Burner fuel pressure

   5 Turbine steam pressure.

i. Boiler water gauge glass shall be provided with scales marked with numerals at each inch from the specified normal water level. Subdivision shall be marked at each one-half inch.

SECTION 5

MAINTENANCE

225-5.1 INTRODUCTION

225-5.1.1 GENERAL. The majority of automatic control equipment found in the machinery spaces of modern naval ships employs compressed air as the working medium. Automatic control equipment and systems of the pneumatic type include Automatic Boiler Control (ABC) controls, boiler Feedwater Control (FWC), main Feed Pump Controls (FPC's), pressure regulators for exhaust and auxiliary steam systems, desuperheater temperature regulators, level controllers for deaerating feed tanks and condenser hot wells, as well as other systems common to each specific ship. These control systems and devices, if properly adjusted during initial startup of the plant, will give long term trouble-free performance only if certain routine maintenance procedures are followed on a regular schedule. The frequency of required maintenance procedures will be greatly reduced if the air supply to control system components is maintained clean and dry. For this reason it is emphasized that air filters should be blown dry once each watch, and the condition of the filter material inspected once each month. The Planned Maintenance System (PMS) schedule should be followed as developed for each individual ship.

225-5.1.2 TROUBLESHOOTING GUIDE. Troubleshooting of a control system containing a large number of elements can be a complex task and should be accomplished by personnel having a good knowledge of a theory of operation of the systems. Although the specific hardware in naval control systems may vary from ship to ship, certain general rules can be formulated as a guide to the general troubleshooting approach. These rules are related to typical symptoms of system or component failure in Table 225-5-1.

225-5.1.3 TYPICAL FAULTS. The troubleshooting guides outline general procedures for typical faults but should not be used in place of the technical manuals. These manuals should always be consulted for specific procedures applicable to specific systems.

225-5.1.4 RULES FOR SATISFACTORY PERFORMANCE. Experience aboard many ships has resulted in several simple rules that promote long term satisfactory performance of automatic equipment. These rules are:

a. Maintain a clean, oil-free air supply.

b. Perform routine maintenance tasks as recommended in the technical manual and PMS schedule.

c. Do not attempt to make adjustments to an operating system that performs satisfactorily.

d. Do not attempt to make adjustments to any system without a thorough understanding of the effect of each adjustment and a knowledge of the desired objective.

e. Do not attempt to calibrate the components of a system without a list of the specified calibration data and an instruction manual.

f. Remember that any control system that has operated properly in the past can be restored to a useful condition through effort and patience. The experience gained in proper care of automatic control systems will benefit the effectiveness of the entire ship.

225-5.2 AUTOMATIC BOILER CONTROL SYSTEMS MAINTENANCE

225-5.2.1 GENERAL. The On-Line Verification (OLV) procedures emphasize maintaining the systems on-line as much as possible. Routinely checking the systems with the static and dynamic check procedures eliminates the need for a lot of component removal and disassembly for maintenance by verifying proper operation on-line (see Section 4). Some preventive maintenance is still required.

Table Table 225-5-1 TROUBLESHOOTING GUIDANCE

Symptom	Action
Controlled variable cannot be maintained in either AUTOMATIC or REMOTE MANUAL	Observe output of control station; if output behaves normally check regulating valve and positioner. If selector station output remains constant under any condition, check selector station trap valves, controller pilot valve or booster, pressure regulator, and so forth. If no output, check air supply pilot valve, pressure regulator, and so forth.
Controlled variable cannot be maintained in AUTOMATIC mode, but can be controlled by REMOTE MANUAL operation.	Check output of all transmitters feeding into the control systems. Output should correspond to conditions measured.
	Check behavior of controller output; if output remains at maximum, controller is internally damaged or badly out of calibration. If output remains at zero, check air supply, boosters, filters, needle valves, and controller calibration.
	If controller output responds to changes in input but will not produce correct value of controlled variable, check setpoint spring or loading pressure, and controller calibration.
Controlled variable oscillates about the setpoint when under automatic control.	If oscillations are high frequency, reduce controller sensitivity; if low frequency, slowly close reset needle valve until oscillation disappears. If oscillations continue; inspect transmitter, actuator, and valve positioner linkages for lost motion or link failure.
Controlled variable holds a proper value at one load, but increases error at other loads.	Check calibration of nonlinear elements, such as characterizing relays or signal shapers.
	Check automatic reset action of controller.
	Check calibration of all transmitters whose outputs change with load.
Control valve or actuator will not respond to position input signal.	Check for mechanical interference. Inspect positioner; adjust pilot valve and observe positioner output. Check positioner linkage. Check air supply to positioner. Check mechanical adjustments in control valve.

Table Table 225-5-1 TROUBLESHOOTING GUIDANCE - Continued

Symptom	Action
Transmitter cannot be properly calibrated.	Disassemble transmitter; inspect primary element devices (bellows, Bourdon tube, gas or liquid filled bulb, area meter, and so forth). Inspect range and suppression springs and associated linkages. Repair as required.

225-5.2.2 SUGGESTED MAINTENANCE REQUIREMENTS. Use a copy of the maintenance schedule to record when each item is accomplished during PMS performance.

1. Calibrate the following gauges once a year using appropriate standards. Such standards include manometers and regulated pressure sources with a calibrated standard gauge for higher range pressure gauges:
   a Steam drum pressure gauges
   b Feedwater header pressure gauge
   c Burner fuel oil pressure gauges
   d Automatic Combustion Control (ACC)/FWC/FPC component output pressure gauges
   e ACC/FWC/FPC automatic/ manual (A/14) control station gauges
   f FPC recirculation control cabinet gauges
   g Forced-draft blower tachometer ammeters on control console.
2. Check calibration of airflow transmitters once a year.
3. Check the calibration of the FPC waterflow transmitters and associated recirculation controls once every 6 months. Use the Supplementary Alignment Procedures of the OLV procedures.
4. Blowdown transmitter impulse (sensing) lines once a year:
   a Drum level transmitter
   b Feedwater flow transmitters
   c Steam flow transmitters
   d Steam pressure transmitters.

CAUTION

Follow procedures in applicable technical manuals. Make sure differential pressure and flow transmitters are equalized and isolated, and pressure transmitters are isolated.

5. Renew bronze air filters in each Barton flow and level transmitter once every 3 months.
6. Check air lock system once a year for proper operation.
7. Perform routine maintenance and lubrication for other components of the ACC/FWC/FPC (for example, feedwater control valves, blowers, and so forth).
8. Perform a complete calibration check and on-line alignment verification of the ACC/FWC/FPC system after any extended period in which the plant is cold (for example, after an overhaul). Use the equipment calibration procedures contained in the applicable Naval Sea Systems Command (NAVSEA) technical manual and the alignment procedures in the OLV procedures, as appropriate.

9. Clean out airflow transmitter sensing lines once a year.

10. Replace filter cartridge elements in air filters once a year.

NOTE

The maintenance items previously mentioned do not include requirements for routine disassembly of the pneumatic control components.

SECTION 6
ACCESSORIES

225-6.1 CALIBRATION EQUIPMENT

225-6.1.1 GENERAL. Many control system problems can be corrected by providing Automatic Boiler Control (ABC) maintenance personnel with the proper equipment necessary to calibrate a control system. A calibration test panel (such as illustrated in Figure 225-6-1), is an example of equipment invaluable for maintaining control systems. Such panels are used to test for proper calibration and operation of components from combustion, feed-water, and feed pump control systems.

225-6.1.2 CALIBRATION TEST PANEL. The calibration test panel includes the several ranges of test gauges and air regulators required for testing the various ABC system components. In addition, a list of recommended tools and portable test equipment to be used for in-place calibration and maintenance of control components is provided with the test panel. The calibration test panel when used with test gauge comparator will serve as a standard calibration source which will have data traceable to the National Bureau of Standards (NBS). This equipment may be used with any pneumatic control systems as a shipboard standard.

225-6.1.3 PORTABLE CALIBRATION EQUIPMENT. Appropriate portable calibration equipment for boiler control system support shall be available for in-place component calibration. It is important that both stationary and portable test equipment is available to the ABC maintenance personnel and that calibration of this equipment is current. A listing of the appropriate portable calibration equipment is provided in Table 225-6-1.

225-6.1.4 CALIBRATION KIT. The calibration kit contains the items identified in the following paragraphs. More detailed information may be obtained from the manufacturer's instructions pertaining to each specific item.

225-6.1.4.1 Slack Tube Manometer. The Dwyer manometer measures differential pressure heads directly in inches of water. The nylon top connectors are sized for 3/16 inch inside diameter (ID) hose or tubing slip-on fit. The connectors turn counterclockwise to open and clockwise to close. Care shall be taken to prevent leaks around these connectors. Ensure that both connector and hex plug O-rings are intact and in place. Application of standard stopcock lubricant will aid in reducing leakage. The manometer is furnished with a small bottle of fluorescein green dye to facilitate observation of level in the tubes. Ten drops of dye per quart of distilled water is recommended. The manometer should be filled approximately half full so that the level in both legs can be set to zero on the movable center scale. The low-pressure connector should be turned counterclockwise to vent the low-pressure leg to atmosphere. The high-pressure connector should also be turned counterclockwise and connected to the device under test.

225-6.1.4.2 Four and One-Half Inch Ashcroft Laboratory Test Gauges. These gauges are intended to accurately measure the signal pressures of the component being calibrated. In addition, the gauges may be used to measure differential beads which are beyond the range of the manometer, but only when one side of the differential pressure measuring device is vented to atmospheric pressure. The following rule is useful for converting from pounds per square inch to inches of water:

1 psi = 27.7 inches of water

1 inch of water = .036 psi

1 foot of water = .433 psi.

LIST OF MATERIAL					
PC NO.	DESCRIPTION	AMT REQD	MATERIAL	REMARKS	APL OR NSN
T−1	.250.00 X .032 THICK	10'0"	COPPER	MIL−T−24107	NSN 4710−00−277−4029
T−2	.250.00 X .065 THICK	3'0"	C.S.	MIL−T−20157 SHLS TYPE E 3000 NSI	
V−1	1/4 IPS GLOBE VALVE 100	1	BRONZE	CRANE CAT 60 PT NO. 1240 OR EQUIVALENT	
V−2	1/4 DIAPHRAGM PANEL VALVE	2	BRASS	PARKER HANNIFIN NO. 4F−V6 LR−5 OR EQUIVALENT	
V−3	1/4 PRECISION RELIEF VALVE	2		CIRCLE SEXAL CO PT NO. 05558−2M−35	
V−4		2		05598−2M−65	
V−5		1		0558−2M−105	
V−6		1		0558−2M−20	NSN 0000−LL−CK6−6300
V−7		1		05598−2M−2	
G−1	2 1/2 DIAL GAUGE 1/8 MPT BACK	1	VARIOUS	0−100 PSIG US GAUGE CORP PT NO. P−845−FF−100	
G−2	2 1/2 DIAL GAUGE 1/8 MPT BACK	1		0−160 PSIG US GAUGE CORP PT. NO. P−845−FF−160	
G−3	6 DIAL GAUGE 1/8 FPT BOT CONN	1		0−400" WALLACE & TIERNAN PT. NO. 62C−2C−0400	
G−4	6 DIAL GAUGE 1/8 FPT BOT CONN	1		0−40" WALLACE & TIERNAN PT. NO. 62C−2C−0040	
G−5	6 DIAL GAUGE 1/4 MPT BOT BACK	2		0−30 PSIG ASHCROFT PT NO. 60−1082AS−028−XEY−30	NSN 6685−00−878−0473
G−6		2		0−60 PSIG ASHCROFT PT. NO. 60−1082AS−028−XEY−60	NSN 6685−00−585−5494
G−7		1		0−100 PSIG ASHCROFT PT NO. 60−1082AS−028−XEY−100	NSN 6685−00−585−5493
G−8		1		0−2000 PSIG ASHCROFT PT NO. 60−1082AS−02L−XEY−2000	NSN 0000−LL−CG2−8558
R−1	PRECISION RGL TR PNL MTD	3	VARIOUS	MOORE PRODUCTS MODEL 41−100	APL 612100057
R−2		1		41−30	APL 612100100
R−3		1		41−15	APL 612100041
R−4		1		40−2	APL 612100130
F−1	1/8 FPT X 1/4 00 FLARE 90° ELBOW	2	BRASS	PARKER CAT. 4310 PT. NO. 4−DBTX−8	NSN 4730−00−767−2615
F−2	1/8 MPT X 1/4 00 FLARE 90° ELBOW	15		4−CXBT−8	NSN 4730−00−855−4977
F−3	1/4 MPT X 1/4 00 FLARE 90° ELBOW	4		4−4CBTX−8	NSN 4730−00−540−1861
F−4	1/4" FLARE BULKHEAD UNION	4		4−WBTX−8	NSN 4730−00−900−3294
F−5	1/4 UNION TEE	6		4−1BTX−8	NSN 4730−00−850−3828
F−6	1/4 MALE RUN TEE	1		4−1RBTX−8	
F−7	1/4 PIPE NIPPLE (LONG HEX)	1		1/4 FFF−8	
F−8	1/4 MPT SQUARE HEAD PLUG	1		1/4 SHP−8	
F−9	1/8 MPT SQUARE HEAD PLUG	5		1/8 SHP−8	
F−10	FEMALE CONN 1/4 FPT X 1/4 00 FERULOK	1	S.S.	4−4 G8U−55	NSN 4730−01−034−3224
F−11	37" BULKHEAD UNION FERULOK	1	S.S.	4−XH28U−55	NSN 4730−00−925−0964
F−12	10−32 X 3/4 SCREW CSK PHH	6	STEEL	CAP PPL FOR G−3 AND G−4	NSN 5305−00−015−6019
F−13	1/4 FPT X 1/4 00 FLARE 90° ELBOW	5	BRASS	PARKER CAT. 4310 PT. NO 4−40BTX−8	

Figure 225-6-1 Automatic Combustion Control Calibration Panel Drawing (Sheet 1 of 13)

LIST OF MATERIAL (Continued)					
PC NO.	DESCRIPTION	AMT REQD	MATERIAL	REMARKS	APL OR NSN
F–14	8–32 X 1/2 SCREW PAN HD	6	STEEL	CAP PPL FOR G–1 AND G–2	NSN 5305–00–043–6695
F–15	10–32 NUT SELF–LOCKING	6			NSN 5310–00–877–5797
F–16	8–32 NUT SELF–LOCKING	6		G–1 AND G–2	NSN 5301–00–658–2994
F–17	1/4–20 NUT SELF–LOCKING	18		FOR G–5, G–6, G–7, AND G–8	NSN 5310–00–208–1919
F–18	STEEL BOLTS	14	STEEL	3.8–15 UNC–2A	
F–19	STEEL BOLTS	4		3/8–24 UNF–2A X 2" LONG	
F–20	HEXAGON JAM NUTS	8		3/8–24 UNF–28 X 21/64 FOR USE WITH F–19	NSN 5310–00–903–1524
L–1	LABEL PLATE	2	PHOTO PLATE	INSCRIPTION 0–400 IN WC	
L–2		2		0–40 IN WC	
L–3		3		0–30 PSIG	
L–4		2		0–60 PSIG	
L–5		3		0–100 PSIG	
L–6		1		0–2000 PSIG	
L–7		1		UNREGULATED AIR SUPPLY TO PANEL	
L–8		1		REGULATED AIR SUPPLY PANEL	
L–9		2		REGULATED AIR SUPPLY CONNECTION	
L–10		2		REGULATED AIR SUPPLY CUT OUT	
L–11		1		OPERATING INSTRUCTIONS AND SAFETY PRECAUTIONS	
AF	AIR FILTER WITH MOUNTING KIT	1	VARIOUS	SUPPLY AIR FILTER MOORE MODEL 30282	APL 480450001
P–1	GAUGE BOARD	1	ALUMINUM	34 X 35 X 1/4 THICK	
P–2	MOUNTING PLATE	1		22 X 15 1/2 X 1/4 THICK	
P–3	HAGAN TOTALIZER MOUNTING BRACKET	1		3 X 7 X 5/16 THICK	
S–1	ANGLE	9'-3"	STEEL	1 1/2 X 1 1/2 X 1/8 THICK	

Figure 225-6-1 Automatic Combustion Control Calibration Panel Drawing (Sheet 2 of 13)

NOTES

GENERAL

1–1 THIS PANEL AND ITS ACCESSORIES ARE INTENDED FOR USE ABOARD SHIPS HAVING AUTOMATIC BOILER CONTROL SYSTEMS AND SHOULD BE INSTALLED FOR SUPPORT OF MAINTENANCE, TEST, AND CALIBRATION OF THIS EQUIPMENT.

1–2 IN ADDITION TO THE LIST OF MATERIAL FOR FABRICATION OF THE PNEUMATIC TEST AND CALIBRATION PANEL, A DESCRIPTION OF RECOMMENDED PORTABLE TEST EQUIPMENT, ACCESSORIES, AND TOOLS REQUIRED FOR MAINTENANCE AND IN-PLACE TESTING AND CALIBRATION OF RELATED EQUIPMENT IS PROVIDED ON SHEETS 8 AND 9. VENDORS LISTED FOR TOOLS AND ACCESSORIES ARE ONLY RECOMMENDED SUPPLIERS. EQUIVALENT EQUIPMENT MAY BE USED.

FABRICATION

2–1 PANEL MATERIAL TO BE ALUMINUM ALLOY COMPOSITION 1100–F ACCORDING TO FEDERAL SPECIFICATION QQ–A–250/1. PANELS SHALL BE FINISH PAINTED WITH ONE COAT FORMULA III, CLASS 2, LIGHT GRAY ENAMEL PER MIL–E–15890.

2–2 LOCATE GAUGE MOUNTING HOLES BY TEMPLATING FROM EQUIPMENT.

2–3 GAUGES (PCS NO. G–3 THRU G–8) SHALL BE AS SPECIFIED IN TABLE L.

2–4 ROUND OFF TOP CORNERS OF MOUNTING PANEL AND BRACKET TO PREVENT INJURIES TO OPERATING PERSONNEL.

2–5 NAVAL STOCK NUMBERS (NSN'S) ARE GIVEN FOR REPLENISHMENT PURPOSES.

2–6 ONE COPY OF THIS DRAWING SHALL BE SUPPLIED WITH EACH PANEL FOR GUIDANCE IN ORDERING REPLACEMENT PARTS.

INSTALLATION

3–1 GAUGE PANEL SHOULD BE LOCATED ABOVE, BUT ISOLATED FROM, A WORK BENCH WITH ADEQUATE CABINET SPACE TO CONTAIN EQUIPMENT, TOOLS, AND ACCESSORIES ON SHEET NO. 8 AND 9. WORKBENCH SHOULD ALSO PROVIDE A SUITABLE TOP SURFACE FOR BOLTING COMPONENT MOUNTING PANEL AND BRACKET SHOWN ON SHEETS 6 & 7, INSTALLING ACTIVITY SHOULD CONSIDER VIBRATION, STRUCTURAL INTEGRITY, ACCESSIBILITY, AND ISOLATION FROM ENVIRONMENTAL HAZARDS WHEN SELECTING MOUNTING LOCATION.

3–2 GAUGE PANEL MOUNTING BRACKETS MAY BE EITHER BOLTED TO BULKHEAD WITH FLANGE, OR WELDED TO BULKHEAD WITHOUT FLANGE, WHICHEVER IS MOST CONVENIENT. GAUGE PANEL SHOULD BE BOLTED TO THE FOUR VIBRATION MOUNTS USING PCS F–19 AND F–20.

3–3 AIR SUPPLY SHALL BE FROM AN OIL- AND WATER-FREE SOURCE WITHIN THE RANGE 80–100 PSIG AND CAPABLE OF PROVIDING A 10 SCFM FLOW AT 80 PSIG.

3–4 GAUGES ARE TO BE CALIBRATED BY LOCAL NAVAL STANDARDS LABORATORY BEFORE INSTALLATION AND CERTIFICATION MADE PART OF SHIP'S RECORDS. FOLLOWING INSTALLATION, CALIBRATION SHALL BE VERIFIED IAW SHIP'S METCAL PROGRAM. GAUGES SHALL BE ENTERED IN THE RECALIBRATION PROGRAM IAW NAVELEX INST 4355.2 OF 26 DECEMBER 1984.

TABLE 1

PRESSURE						
	PSIG				INCHES	WATER
RANGE	30	60	100	2000	400	40
FIG. INTERVALS	2	5	5	100	20	5
MINOR SUB DIV	0.2	0.2	0.5	10	2	0.2
ACCURACY (% OF F.S.)	1/4	1/4	1/4	1/4	1/3	1/3
CASE MATERIAL	C.L.	C.L.	C.L.	C.L.	AN AL	AN AL
CONNECTIONS	BACK 1/4 MPT	BACK 1/4 MPT	BACK 1/4 MPT	BACK 1/4 MPT	BOTTOM 1/8 FPT	BOTTOM 1/8 FPT
DIAL – 6 SIZE WITH ANTIPARALLAX MIRROR & KNIFE–EDGE POINTER						
MOUNTING – FRONT FLANGE WITH HINGED COVER. GAUGE GLASS – NONGLARE						

Figure 225-6-1 Automatic Combustion Control Calibration Panel Drawing (Sheet 3 of 13)

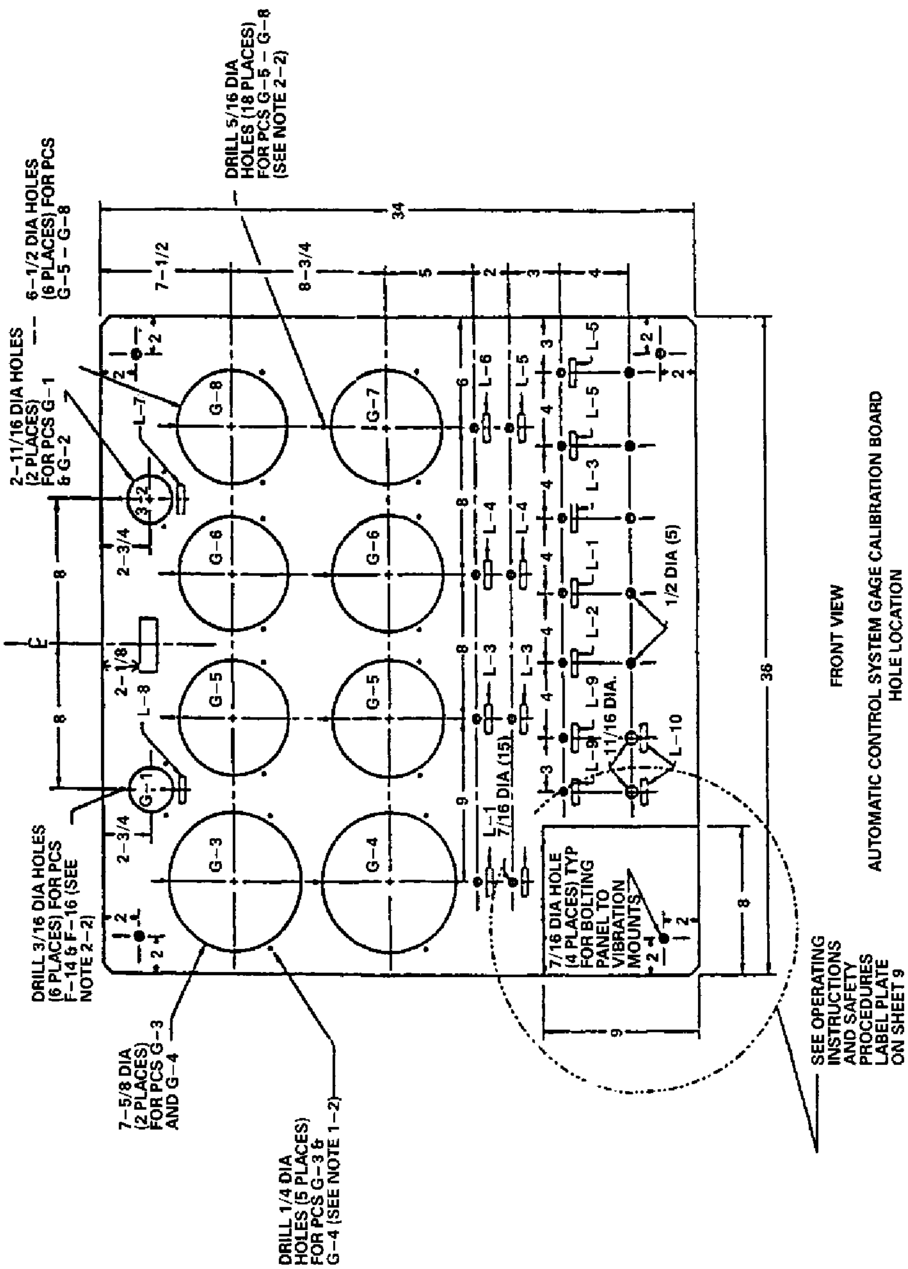


Figure 225-6-1 Automatic Combustion Control Calibration Panel Drawing (Sheet 4 of 13)

LIST OF MATERIAL					
PT. NO.	DESCRIPTION	AMT. REQD	MATERIAL	REMARKS	APL OR NSN
S-2	STEEL BEAM		STEEL	1x22x1/8 THICK	
S-3	STEEL MOUNTING BRACKET		STEEL	2-1/2x17-1/2x1/4 THICK	
VM	VIBRATION MOUNTS		VARIOUS	BARRY CONTROLS P/N T64-AB-50	NSN-5340-00-706-2830

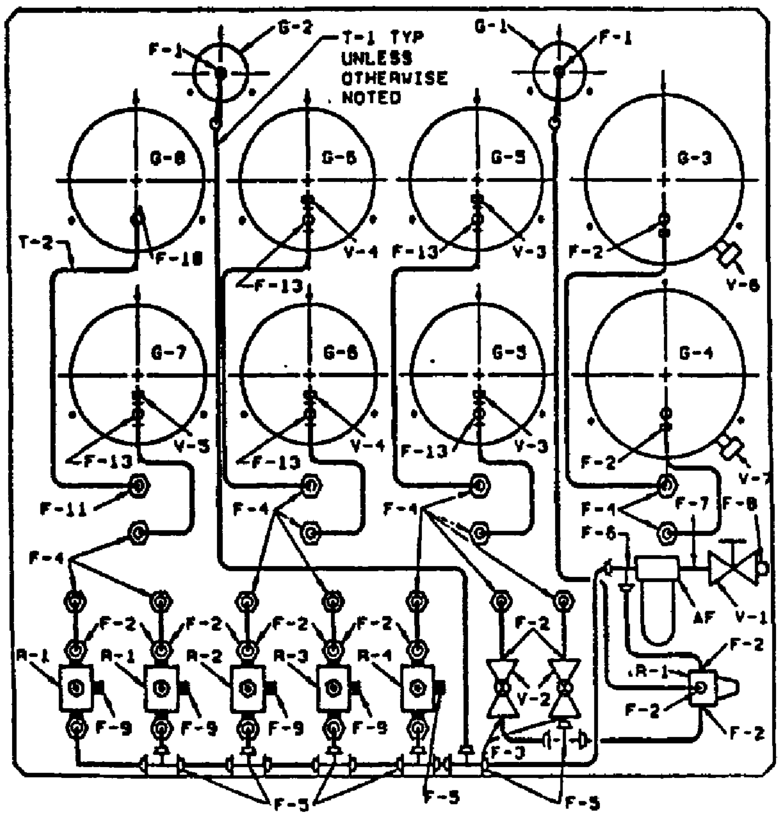


Figure 225-6-1 Automatic Combustion Control Calibration Panel Drawing (Sheet 5 of 13)

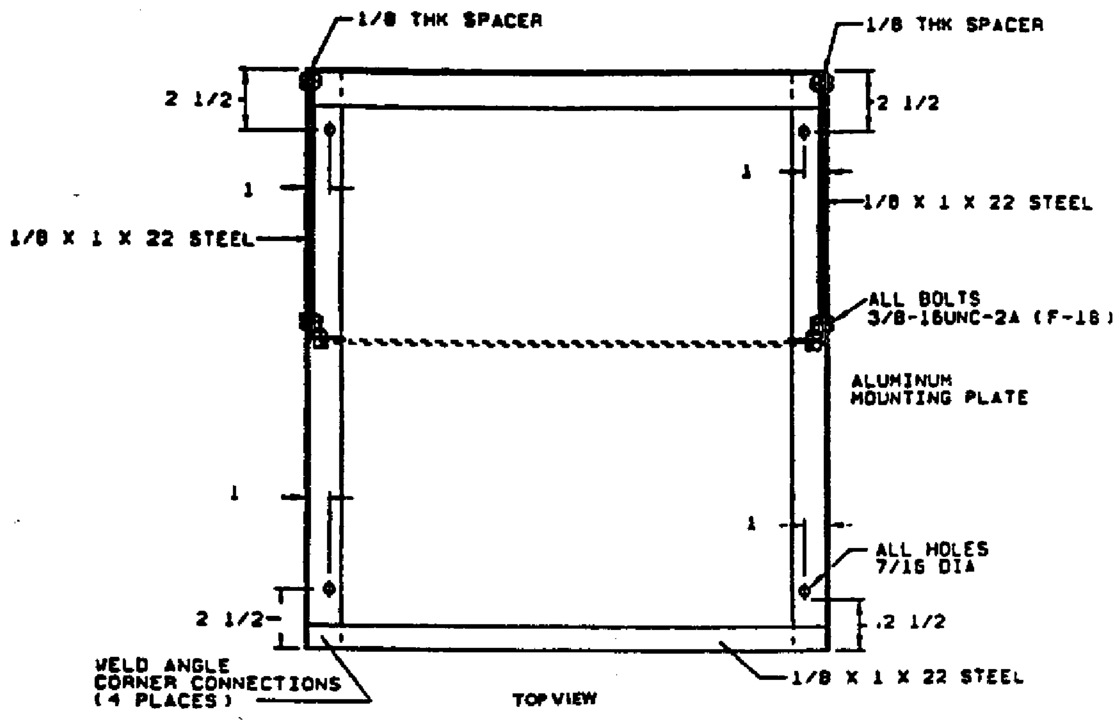


Figure 225-6-1 Automatic Combustion Control Calibration Panel Drawing (Sheet 6 of 13)

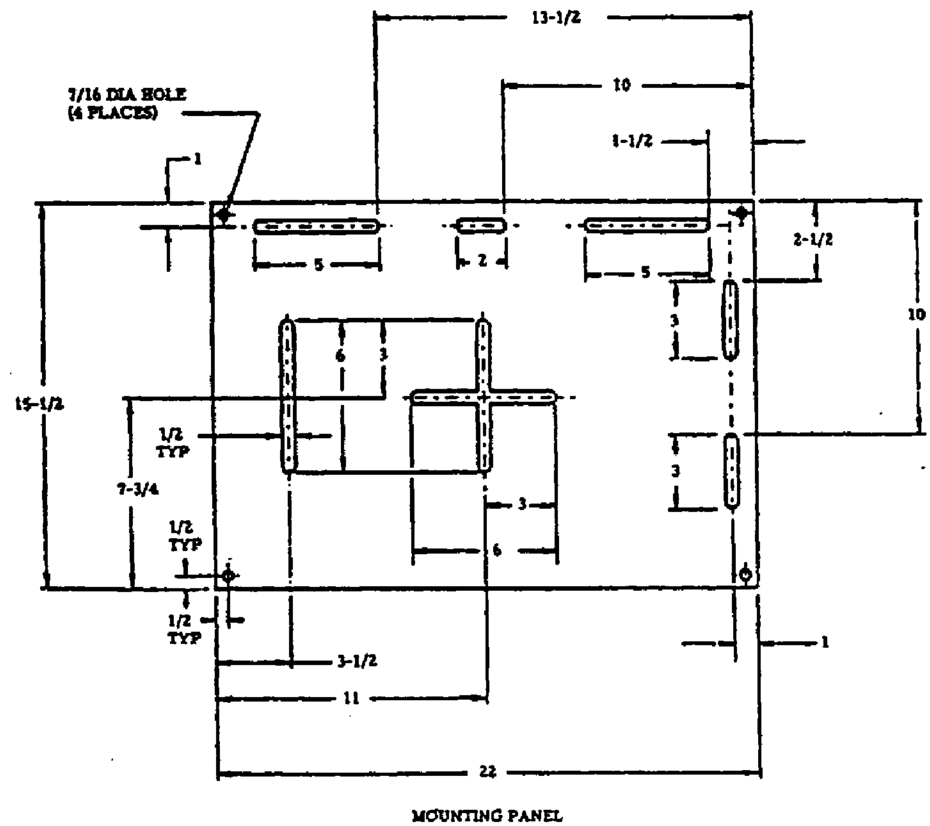


Figure 225-6-1 Automatic Combustion Control Calibration Panel Drawing (Sheet 7 of 13)

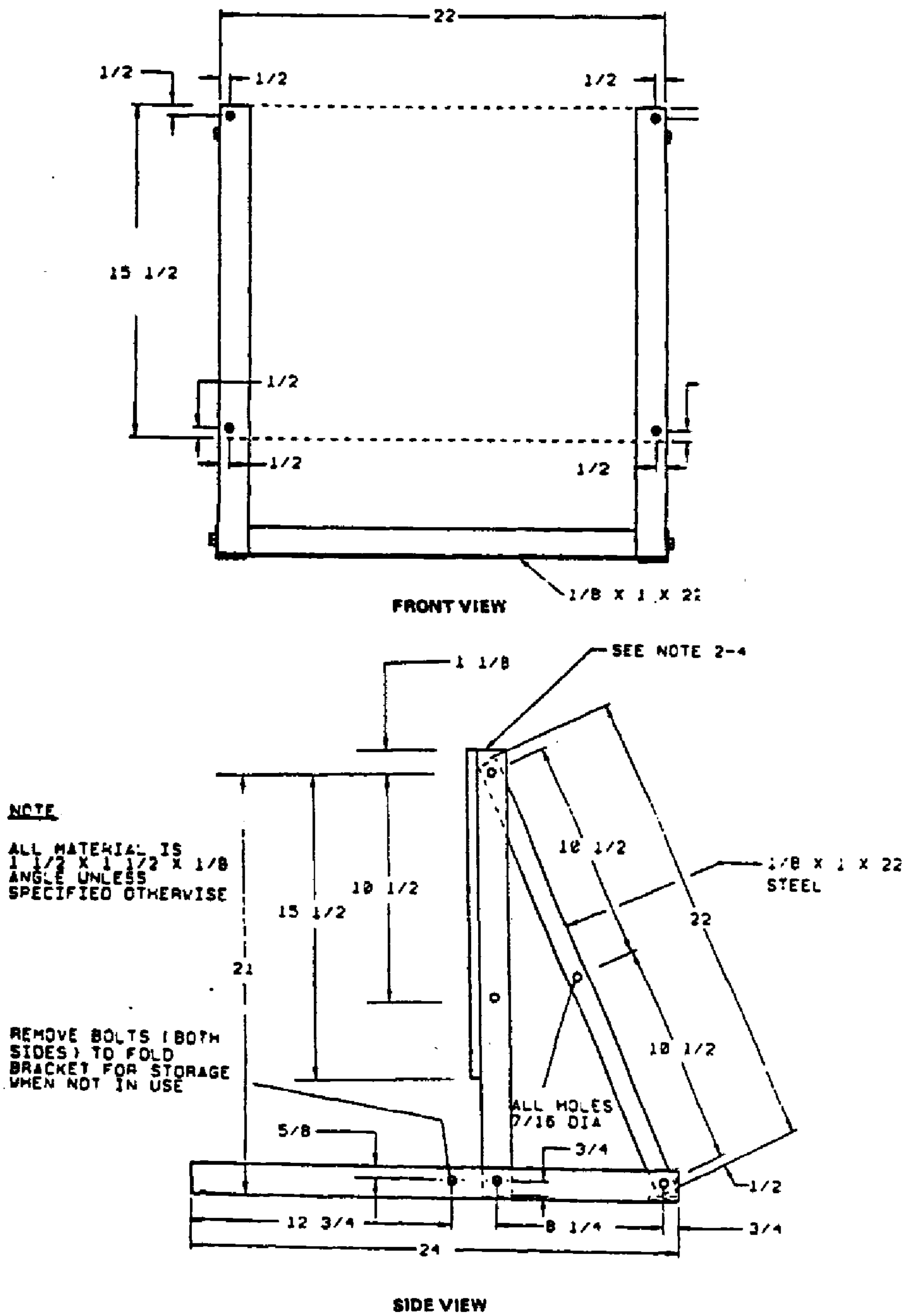


Figure 225-6-1 Automatic Combustion Control Calibration Panel Drawing (Sheet 8 of 13)

QUANTITIES FOR ONE SHIP						
PC NO.	DESCRIPTION	QTY	MANUFACTURER	MANUFACTURER NO	NSN	REMARKS
PORTABLE TEST EQUIPMENT AND ACCESSORIES						
1	MANOMETER, SLACK–TUBE, FLEX (36 H20 18–0–18)	1	F. W. DWYER	1211–36	9G–6685–00–857–4895	RANGE: 36 WITH PART NO. A–316 CONNECTION 1/8 FPT
2	GAUGE, TEST, 0–30 PSIG 4–1/2 DIAL	2	MANNING, MAXWELL & MOORE	1082A	IH–6665–00–878–0493	
3	GAUGE, TEST, 0–30 PSIG 4–1/2 DIAL	2	MANNING, MAXWELL & MOORE	1082A	IH–6685–00–585–5494	
4	REGULATOR, 0–100 PSIG	2	MOORE PRODUCT	41–100	9G–6685–01–051–6693	CONNECTION: 1/8 FPT
5	TESTER, COMPARATOR, GAUGE	1	AME TEK	AME TEK	IH–6685–00–821–0791	RANGE: 0–160, 0–600, 0–1000, AND 0–3000 PSIG
6	REGULATOR, 0–15 PSIG	2	MOORE PROD	41–15	IH–6685–00–884–8158	CONNECTION: 1/8 FPT
7	HOSE H.P. (YELLOW JACKET) 36' LONG	10	IMPERIAL EASTMAN	336FTY	9G–4720–00–603–9259	1/4 O.D. FLARE
8	GAUGE, TEST, 0–400 H20, 2–3/4 DIAL	1	WALLACE TIERNAN	620–2C–0400	–––––––	CONNECTION, 1/8 FPT
9	TEFLON TAPE	6			8030–00–889–3535	
10	LEAK DETECTOR	12			6680–00–186–2963	
11	STOPWATCH	1				
TOOLS						
1	WRENCH OPEN END, DOUBLE HEAD, 15 AND 75	1	SNAP–ON TOOLS	DS–1212	–––––––	SIZE: 3/16 X 3/16
2	60		PROTO	3210	90–5120–00–277–3414	13/64 X 15/64
3				3215	277–8308	7/32 X 1/4
4				3221	277–8311	9/32 X 5/16
5				3225	277–8313	11/32 X 3/8
6				1725	187–7173	7/16 X 1/2
7		2		1727	187–7126	9/16 X 5/8
8		1		1029C	–––––––	11/16 X 13/16
9	BOX, OFF-SET, DOUBLE HEAD, 12 POINT		SNAP–ON TOOLS	XID– 1213	–––––––	3/16 X 13/64
10				1415	–––––––	7/32 X 15/64
11				1618	–––––––	1/4 X 9/32
12				2022	–––––––	5/16 X 11/32
13				XS 1012	–––––––	5/16 X 3/8
14				1214	90–5120–00–224–3146	3/8 X 7/16
15				1416	596–8556	7/16 X 1/2
16				1618	277–3364	1/2 X 9/16
17		2		1820	224–3148	9/16 X 5/8
18		1		2024	277–1437	5/8 X 3/4
19		1		2226	–––––––	11/16 X 13/16
20	OPEN END, ADJUSTABLE, SINGLE END	2	J. WILLIAMS AND CO	AP–6	90–5120–00–264–3795	6
21		1		AP–8	240–5328	8
22		1		AP–10	278–0341	10

Figure 225-6-1 Automatic Combustion Control Calibration Panel Drawing (Sheet 9 of 13)

QUANTITIES FOR ONE SHIP (Continued)

PC NO.	DESCRIPTION	QTY	MANUFACTURER	MANUFACTURER NO	NSN	REMARKS
23	SOCKET SET, 3/8 SQUARE DRIVE, 12 POINT	1	J. WILLIAMS AND CO	SFT NO. WS8–9	–––––––	
24	SCREWDRIVER, FLAT TIP	2	STANLEY TOOLS	EDP NO. 62–364	90–5120–00–905–6730	BLADE LENGTH 4
25				62–366	596–8653	6
26				65–162	541–3004	12
27	.CLOSE QUARTER			65–165	–––––––	1
28	CROSS TIP			64–102	90–5120–00–224–7375	4
29	CROSS TIP			64–104	–––––––	8
30	JEWELER	1	MCMASTER CARR SUPPLY		90–5120–00–180–0705	TIP: 0.025
31					0706	0.040
32					0777	0.055
33					0728	0.070
34					0729	0.080
35					0730	0.100
36	PLIERS, SLIP JOINT, COMBINATION JAWS	2	J. WILLIAMS AND CO	PL–6	223–7396	LENGTH: 6
37	SLIP JOINT, COMBINATION JAWS	1	J. WILLIAMS AND CO	PL–8	223–7397	LENGTH: 8
38	RETAINING RING, EXTERNAL		SNAP–ON TOOLS	PR–22	228–9711	
39	LONG NOSE WITH CUTTER			196	293–0032	NOMINAL SIZE: 7
40	DIAGONAL CUTTING			86	–––––––	NOMINAL SIZE: 6
41	BENDER, TUBE, HAND		PARKER/HANNIFIN	4–2829 1/4 O.D.	90–5120–00–240–0152	TUBE O.D.: 1/4″
42	BENDER, TUBE, HAND		PARKER/HANNIFIN	6–2829 3/8 O.D.	240–0154	TUBE O.D: 3/8″
43	TWEEZERS		MCMASTER CARR SUPPLY	56A691	247–0868	NOMINAL LENGTH: 4–1/2
44	KIT, TUBE CUTTING AND FLARING		PARKER/HANNIFIN		–––––––	37″ FLARE
45	PUNCH, DRIVE PIN		SNAP-ON TOOLS	PPC– 103	90–5120–00–242–3435	POINT DIA. 3/32
46				104	242–5966	1/8
47				105	240–6104	5/32
48				104	223–1015	3/16
49				108	223–1016	1/4
50				110	223–1017	5/16
51	PRICK		J. WILLIAMS AND CO	P–30	224–7446	
52	HAMMER, MACHINIST, BALL–PEEN		BLUE POINT	BP–BA	061–8541	WEIGHT: 1/2 LB (SOLD BY SNAP–ON)
53	SCRIBER MACHINIST	2	BROWN AND SHARP	599 778–1	224–9728	
54	BOX TOOLS	1	SNAP–ON TOOLS	KRA580	–––––––	NOMINAL SIZE: 26 X 12 X 14
55	WRENCH, HEX HEAD, L–SHAPED, DOUBLE END			AW035	–––––––	SIZE: 0.035
56	WRENCH, HEX HEAD, L–SHAPED, DOUBLE END			AW 050	–––––––	SIZE: 0.050
57	WRENCH, HEX HEAD, L–SHAPED, DOUBLE END			AW 2	–––––––	SIZE: 1/16
58	WRENCH, HEX HEAD, L–SHAPED, DOUBLE END			AW 2–1/2	–––––––	SIZE: 5/64

Figure 225-6-1 Automatic Combustion Control Calibration Panel Drawing (Sheet 10 of 13)

QUANTITIES FOR ONE SHIP						
PC NO.	DESCRIPTION	QTY	MANUFACTURER	MANUFACTURER NO.	NSN	REMARKS
			TOOLS			
59	WRENCH, HEX HEAD, I-SHAPED DOUBLE END	1	SNAP-ON-TOOLS	AW–3	90–5120–00–242–7410	SIZE: 3/32
60				3-1/2		7/64
61				4	90–5120–00–240–5292	1/8
62				4-1/2		9/64
63				5	90–5120–00–198–5392	5/32
64				6	240–5300	3/16
65				7	242–7411	7/32
66				8	224–4659	1/4
67				10	240–5274	5/16
68				12	198–5390	3/8
69				14	240–5277	7/16
70				16	198–5391	1/2
71	WRENCH, HEX HEAD, L-SHAPED DOUBLE END	1	SNAP-ON-TOOLS	AW–18	90–5120–00–240–5268	SIZE: 9/16
72	ADAPTER NOZZLE PRESSURE	1	– – – – – –			
73	PEN CLEANING WIRE, RESTRICTOR CLEANING	6	– – – – – –			
74	IGNITION WRENCH FLAT 3/8	1	– – – – – –			
75	WRENCH, HEX HEAD L-SHAPED, DOUBLE END	12	– – – – – –			SIZE: 028
76	WRENCH, HEX HEAD SOCKET TYPE	1	SNAP-ON-TOOLS	TMA–6		SIZE: 3/16
77	WRENCH, TORQUE CLICK TYPE	1	SNAP-ON-TOOLS	OJR–117		SIZE: 1/4 SQUARE DRIVE
78	PEN CLEANING WIRE, RESTRICTOR CLEANING	5	ITT BARTON	(33–012–003)		
79	ITT BARTON CALIBRATION KIT	2	ITT BARTON	0273	90–6685–00–032–7903	

L–11 OPERATING INSTRUCTIONS AND SAFETY PROCEDURES

1. ENSURE AIR SUPPLY IS TAKEN FROM AN OIL– AND WATER–FREE SOURCE.
2. BLOW DOWN AIR FILTER BEFORE EACH USE AND CHANGE FILTER QUARTERLY TO PREVENT CONTAMINATED AIR FROM ENTERING THE SYSTEM.
3. SECURE AIR SUPPLY TO THE CALIBRATION PANEL WHEN NOT IN USE.
4. DO NOT EXCEED GAUGE'S MAXIMUM PRESSURE READING.
5. DO NOT MAKE SUDDEN CHANGES TO GAUGE INPUTS BY EITHER CONNECTING OR DISCONNECTING A PRESSURIZED HOSE.
6. DO NOT TAP ON GAUGE FACE OR IMPACT GAUGE BOARD SINCE IT MAY AFFECT GAUGE CALIBRATION.

OPERATING INSTRUCTIONS AND SAFETY PROCEDURES
ATTACHED TO AUTOMATIC CONTROL SYSTEM GAUGE CALIBRATION BOARD.

Figure 225-6-1 Automatic Combustion Control Calibration Panel Drawing (Sheet 11 of 13)

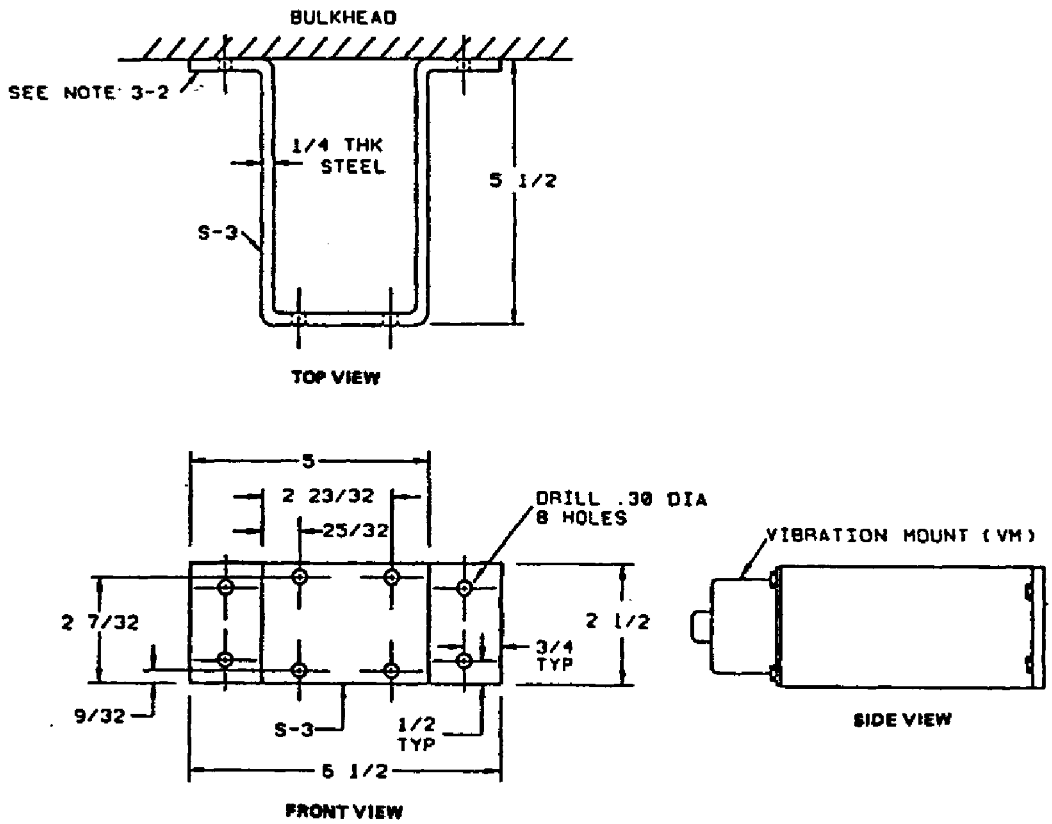


Figure 225-6-1 Automatic Combustion Control Calibration Panel Drawing (Sheet 12 of 13)

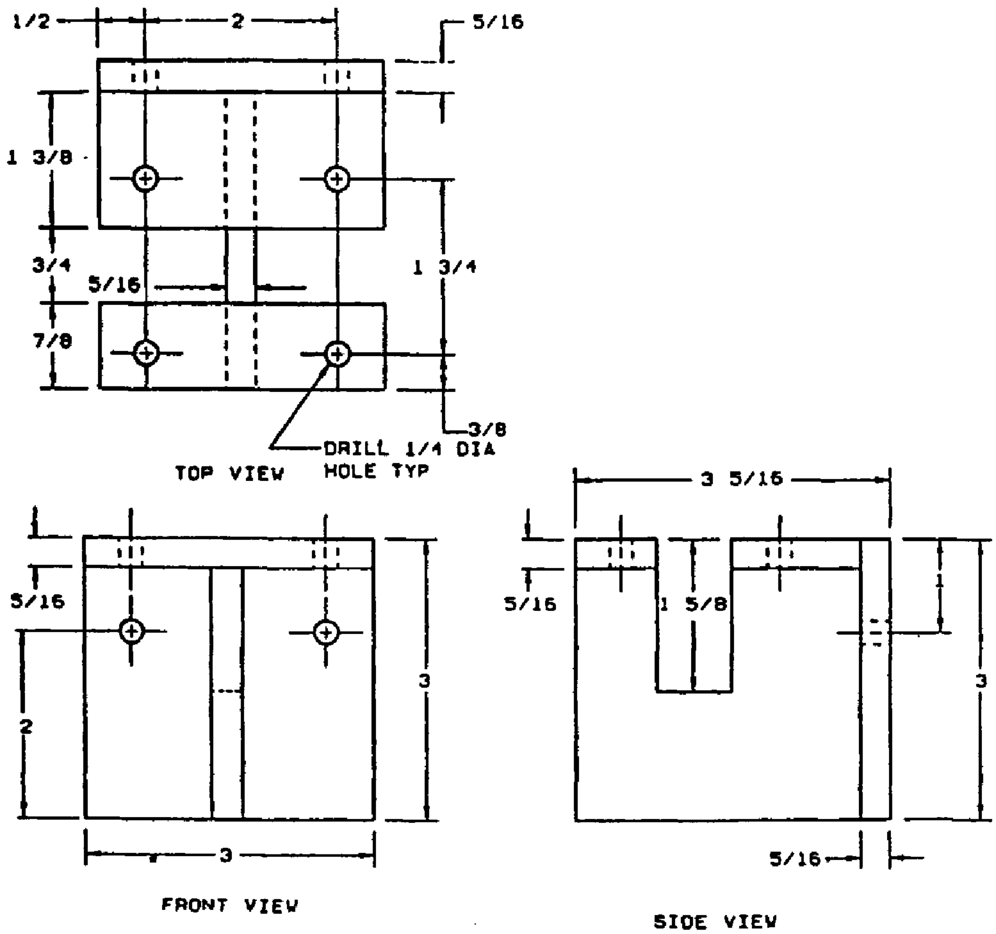


Figure 225-6-1 Automatic Combustion Control Calibration Panel Drawing (Sheet 13 of 13)

Table 225-6-1 LIST OF RECOMMENDED COMPONENTS FOR CALIBRATION OF AUTOMATIC COMBUSTION AND FEED WATER CONTROLS

Recommended Components	
1. Manometer Slack Tube - Flexible Range: 36″ Dwyer Cat. No.: 1211-36 Price - $38.00	
Dwyer Instruments Incorporated P.O. Box 373 Michigan City, IN 46360	
2. 4-1/2″ Laboratory Test Gauge Cat. No.: 1082A-(pressure) Bottom Connection	
Range	Intermediate Graduation
0-15 psi	0.1 psi
0-30 psi	0.2 psi
Price - $95.00	
Ashcroft	

Table 225-6-1 LIST OF RECOMMENDED COMPONENTS FOR CALIBRATION OF AUTOMATIC COMBUSTION AND FEED WATER CONTROLS - Continued

Recommended Components			
3. Tube cutter & 37° Flaring Block and Die Kit GSA 5180-00-293-2867			
4. Nullmatic Pressure Regulator			
Model No.		Range	
41-15.		0-15 psi	
41-100.		0-100 psi	
Moore Products Company Sunneytown Pike Spring House, PA 19477			
5. Comparator, Gauge Tester 1H-6685-00-821-0791			
6. Key, socket head screw hexagonal-L-type, double end:			
	Dimensions, Inches		
Stock No.	Distance Across Flats	Nominal Length	
9G5120-00-198-5398	1/16.		
9G5120-00-224-2504	5/64	S	
9G5120-00-242-7410	3/32	H	
	7/64	O	
9G5120-00-240-5292	1/8	R	
	9/64	T	
9G5120-00-198-5392	5/32		
9G5120-00-240-5300	3/16	S	
9G5120-00-242-7411	7/32	E	
9G5120-00-240-4659	1/4	R	
9G5120-00-240-5274	5/16	I	
9G5120-00-198-5390	3/8	E	
9G5120-00-240-5277	7/16	S	
9G5120-00-198-5391	1/2		
9G5120-00-240-5268	9/16		
7. Screwdrivers:			
a. Flat tip, normal duty.			
	Blade Dimensions, Inches		
Stock No.	Nominal Size or Length Under Handle	Shank Dia. or Width and Tip Size at End	Thickness of Tip at End
9GSA5120-00-561-8021	3-3/4	.025	.032
9G5120-00-278-1282>	4	1/4	.037

Table 225-6-1 LIST OF RECOMMENDED COMPONENTS FOR CALIBRATION OF AUTOMATIC COMBUSTION AND FEED WATER CONTROLS - Continued

Recommended Components			
9G5120-00-278-1283	6	5/16	.042
9G5120-00-278-1280	8	3/8	.050
9G5120-00-764-8061	12	3/8	.050
b. Close quarter.			
	Blade Dimensions, Inches		
Stock No.	Nominal Size or Length Under Handle	Shank Dia. or Width and Tip Size at End	Thickness of Tip at End
9G5120-00-222-8866	1	7/32	.032
9G5120-00-278-1273	1-3/4	5/16	.042
c. Cross tip.			
	Blade Dimensions, Inches		
Stock No.	Nominal Size or Length Under Handle	Shank Dia. or Width and Tip Size at End	Thickness of Tip at End
9G5120-00-596-0866	3	3/16	
9G5120-00-580-2361	10	3/16	__
9G5120-00-237-8173	4	1/4	__
9G5120-00-237-8172	6	5/16	__
9G5120-00-237-8174	8	3/8	__
d. Jeweler’s swivel knob.			
	Blade Dimensions, Inches		
Stock No.	Nominal Size or Length Under Handle	Shank Dia. or Width and Tip Size at End	Thickness of Tip at End
9G5120-00-180-0705	3-3/4	.025	.004
9G5120-00-180-0706	3-3/4	.040	.004
9G5120-00-180-0727	3-3/4	.055	.006
9G5120-00-180-0728	3-3/4	.070	.006
9G5120-00-180-0729	3-3/4	.080	.008
9G5120-00-180-0730	3-3/4	.100	.010
e. Screw Starting.			
	Blade Dimensions, Inches		
Stock No.	Distance Across Flats	Nominal Length	
9G5120-00-293-3171	4	7/32	
9G5120-00-293-3159	6	5/32	

Table 225-6-1 LIST OF RECOMMENDED COMPONENTS FOR CALIBRATION OF AUTOMATIC COMBUSTION AND FEED WATER CONTROLS - Continued

Recommended Components			
9G5120-00-242-3133	8	3/8	
9G5120-00-293-3178	10	5/32	
8. Barton Transmitter Kits:			
Stock No.	Name		
9G6685-00-302-7890	Restrictor Assy		
9G6685-00-302-7903	Calibration Kit		
9. Pliers:			
a. Slip joint, combination jaw.			
Stock No.	Nominal Size, Inches		
9G5120-00-223-7396	6		
9G5120-00-223-7397	8		
b. Retaining ring, external.			
Stock No.	Size Range, In.	Tip Diameter	Overall Length
9G5120-00-288-9711	0.18-0.23	0.023	5-5/16
c. Long nose, with cutter.			
Stock No.	Nominal Size, Inches		
9G5120-00-293-0032	7		
d. Diagonal Cutting, Stock No. GSA 5110-00-239-8253, 6″.			
e. e. Parrot-nose, serrated jaws, Stock No. GSA 5120-00-059-6711.			
10. Punch:.			
a. Drive pin 4″ standard length.			
Stock No.	Shank Diameter, In.		
GSA-5120-00-242-5966	1/8		
GSA-5120-00-293-0791	3/16		
GSA-5120-00-240-6083	1/4		
GSA-5120-00-293-0793	5/16		
GSA-5120-00-273-0001	3/8		
b. Prick punch; Stock No. GSA 5120-00-224-7446; 3/8″ x 4″, Size -2.			

Table 225-6-1 LIST OF RECOMMENDED COMPONENTS FOR CALIBRATION OF AUTOMATIC COMBUSTION AND FEED WATER CONTROLS - Continued

Recommended Components			
11. Hammer, machinist, ball-peen; Stock No. GSA-5120-242-3913; 1/2 lb.			
12. Scriber, machinist, Stock No. GSA 5120-00-224-9728; 1/2″ x 6″.			
13. Wrenches:			
a. Open-end, double head, 15 and 60° angles (thin head).			
	Dimensions, Inches		
Stock No.	Wrench Openings	Overall Length Approx	Maximum Head Thickness
	3/16x1/4	3	7/64
	9/32x11/32	3-1/2	1/8
	5/16x3/8	3-3/4	1/8
	7/16x1/2	4	5/32
	9/16x5/8	4-5/8	3/16
b. Box, angular offset, or 45° offset double head, 12 pt.			
	Dimensions, Inches		
Stock No.	Wrench Opening	Overall Length Approximately	
	3/16x1/4	3-1/8	
9G5120-00-224-3135	3/8x7/16	4	
9G5120-00-224-3136	1/2x9/16	4-3/4	
9G5120-00-224-3140	9/16x5/8	5	
9G5120-00-224-3141	5/8x11/16	5-1/2	
c. Socket, spinner type, 12pt, plastic handle, with bolt clearance hole dreilled in shank.			
	Dimensions, Inches		
Stock No.	Wrench Opening	Overall	
9G5120-00-224-2599	3/16	5	
9G5120-00-241-3188	1/4	5-1/2	
9G5120-00-224-2596	5/16	5-3/4	
9G5120-00-596-1263	3/8	6-1/2	
9G5120-00-222-1499	7/16	7-1/2	
9G5120-00-293-0375	1/2	7-1/2	
9G5120-00-294-9514	9/16	7-1/2	
9G5120-00-542-4571	5/8	7-1/2	
d. Open-end, adjustable single end.			
Stock No.	Nominal Size, Inches		
5120-00-264-3795	3/4x6		
5120-00-240-5328	15/16x8		

Table 225-6-1 LIST OF RECOMMENDED COMPONENTS FOR CALIBRATION OF AUTOMATIC COMBUSTION AND FEED WATER CONTROLS - Continued

Recommended Components	
e. Socket set, 3/8 sq drive, regular length 12 pt.	
Stock No.	Size of Socket Opening, Inches
5120-00-322-6231	5/16, 3/8, 7/16, 1/2, 9/16, 5/8, 11/16, 3/4
	Complete with ratchet, hinged handle, universal joint, 6″ and 9″ extension bar.
14. 14. Tweezers; Stock No. GSA 5120-00-247-0868, 4-1/2″.	
15. Hand Tube Bender	
1/4″ OD Tube - 5120-00-234-8739	
3/8″ OD Tube - 5120-00-234-8741	
16. Teflon Tape 1/4″ Width, Stock No. 8030-00-889-3535	
17. Leak Detector, Stock No. 6850-00-186-2963	
18. Tube and Fittings	
a. 37° Flare Fittings	
1/4″ MPT x 1/4″ OD Male Connector	
1/8″ MPT x 1/4″ OD Male Connector	
1/4″ MPT x 3/8″ OD Male Connector	
1/8″ MPT x 3/8″ OD Male Connector	
1/4″ FPT x 1/4″ OD Female Connector	
1/8″ FPT x 1/4″ OD Female Connector	
1/4″ OD Union Tee No NSN	
1/4″ OD Union Elbow No NSN	
1/4″ OD Union 4730-00-894-2794	
3/8″ OD Union Tee 4730-00-810-8536	
3/8″ OD Union Elbow No NSN	
3/8″ OD Union No NSN	
7/16″-20x1/4″ OD Str. No NSN	
Thd. Connector	
1/4″ OD Cap 4730-00-278-5006	
3/8″ OD Cap 4730-00-647-3326	
1/4″ OD Plug No NSN	
3/8″ OD Plug No	
1/4″ OD Nut & Sleeve 4730-00-684-6022	
3/8″ OD Nut & Sleeve 4730-00-203-2661	
b. Tubing 1/4″ OD Copepr Tube (50 ft roll)	
3/8″ OD Copper Tube (50 ft roll)	
3/8″ OD Stnls Stl Tube (20 ft straight)	

Since these gauges are laboratory type, they should be read only when in vertical position and at eye level. Care should be taken during handling of the gauges to prevent excessive shock or vibration.

225-6.1.4.3 Nullmatic Pressure Regulator. The regulator can provide easily regulated, accurate, and steady pressures for calibration of components. The pressure regulator has a volumetric capacity large enough to overcome a small amount of leakage in the system. Care shall be taken to ensure that the unit is not connected backwards. These regulators are marked with an arrow to indicate the proper installation position.

225-6.1.4.4 AMTEK Comparator. The AMTEK comparator is a self-contained unit, requiring no supporting equipment and capable of testing high-pressure components.

SECTION 7

GOVERNORS, CONTROLLERS, PIPING, AIR SUPPLY, AND AIR LOCK SYSTEMS

225-7.1 INTRODUCTION

225-7.1.1 This section describes the following types of steam machinery control systems:

a. Woodward governors

b. Hagan feed pump controller

c. High-pressure piping

d. Pneumatic piping

e. Air supply and air lock systems.

225-7.2 WOODWARD GOVERNORS

225-7.2.1 GENERAL. A Woodward governor (Figure 225-7-1) is used to control Main Feed Pump (MFP) or forced-draft blower speed. This is accomplished by the positioning of a steam admission valve controlling steam flow to the MFP or forced-draft blower turbine drive.

225-7.2.2 DESCRIPTION. The governor receives a pneumatic loading signal from the MFP or forced-draft blower automatic/manual control station. This loading signal is converted to hydraulic pressure which positions a pilot valve. The pilot valve increases or decreases pilot oil pressure which positions the steam admission proportionally to the loading pressure. Actual pump or blower speed is measured by a flyball mechanism inside the governor. This signal is used as the error signal between demand loading signal and actual pump or blower speed. For more detail on the Woodward governor, consult the manufacturer's bulletin.

225-7.3 HAGAN PNEUMATIC HYDRAULIC FEED PUMP CONTROLLER

225-7.3.1 GENERAL. On some ship classes, the MFP's are controlled by a pneumatic hydraulic control system (Figure 225-7-2) which maintains a constant feed pump discharge pressure. All of the pumps in service at any time are operated automatically and by their individual governor. The control system consists of a hydraulic system which utilizes lube oil as a control medium, and a pneumatic system which utilizes air as a control medium. A pneumatic hydraulic pressure controller is mounted on each turbine. The pneumatic Feed Pump Control (FPC) system components for the main feed pump are located in a control panel in the fireroom.

225-7.3.2 DESCRIPTION. The pilot oil piping connects the speed limiting governor, the pneumatic hydraulic pressure controller, and the servo motor which operates the governor valve. The control of the governor valve is effected by varying the pressure in the pilot oil piping, which is accomplished by either the speed limiting governor or the pneumatic hydraulic pressure controller. Oil is supplied at a constant pressure to an orifice. The leakage of oil effected by either the speed limiting governor or pneumatic hydraulic pressure controller modulates the pilot oil pressure. An orifice limits the flow of power oil to the servo motor. The pressure in the pilot oil piping is modulated by the pneumatic hydraulic pressure controller by varying the force of a spring to the cup valve where leakage of oil occurs. The spring, which is connected to bellows by a valve rod, registers the oil signal pressure in terms of spring force on the cup valve. Any change in air signal pressure on the bellows, which is opposed by the spring, results in a change in pilot oil pressure which, by effecting a change in governor valve position, causes a corresponding turbine speed change.

225-7.3.3 THEORY OF OPERATION. The hydraulic control system performs two functions. It regulates the speed of the turbine (and pump) so that the discharge pressure from the pump will be constant (usually 1,450 psig for 1,200 psig boilers and 800 psig for 600 psig boilers). It limits the speed of the turbine to prevent failure of rotating components and bearings which would result from excessive speed.

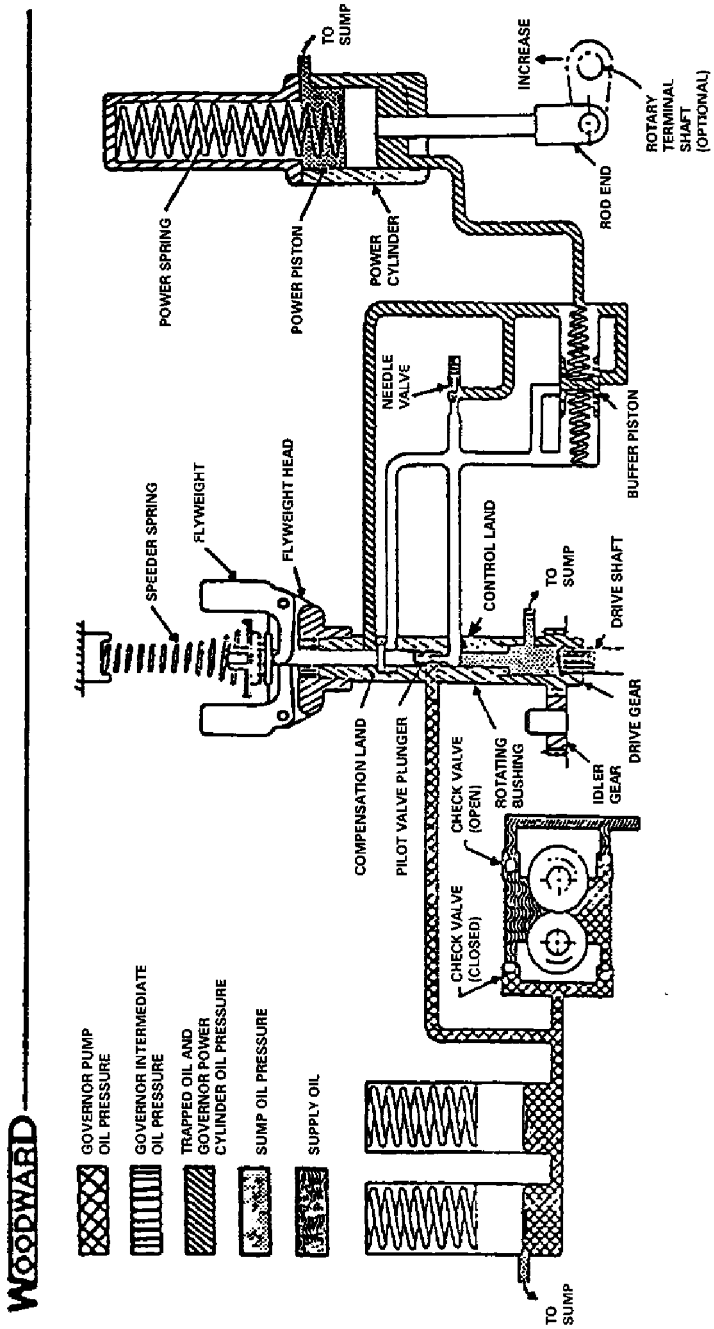


Figure 225-7-1 Woodward Governors

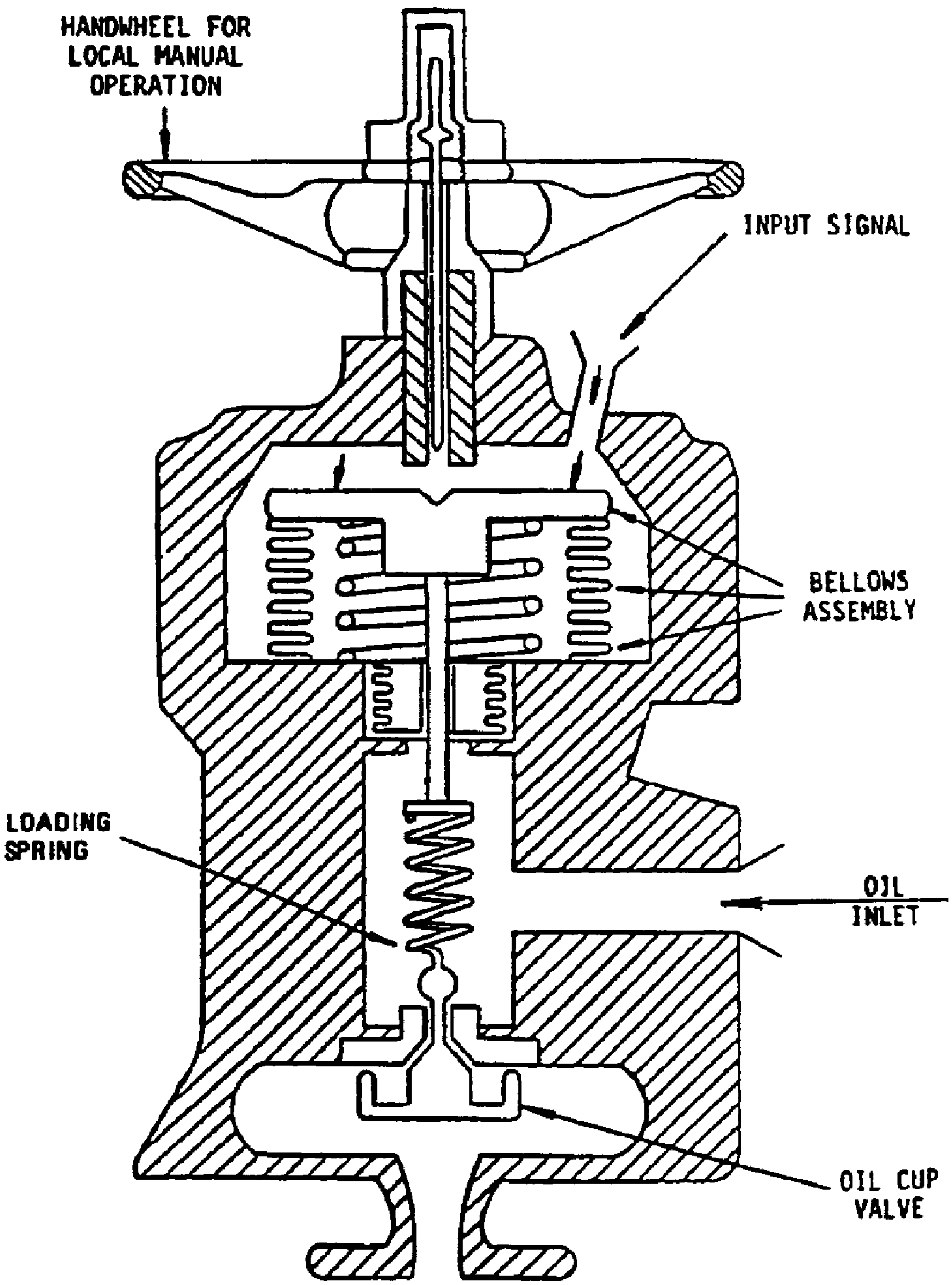


Figure 225-7-2 Pneumatic Hydraulic Pressure Controller (Increase in Input Signal Will Decrease Pump Pressure (Speed))

225-7.3.3.1 Cup Valves. The pilot oil pressure is modulated by two cup valves, one operated by the speed limiting control, the other by the pneumatic hydraulic controller. These cup valves are equivalent to variable area orifices. A fixed area orifice is located ahead of the cup valves in the pilot oil line so that any change in opening of the cup valve results in corresponding change of pressure of the pilot oil. Each regulating device (cup valve) controls independently the position of the governing valve by varying the pressure in the pilot oil line. The speed limiting control overrides the pneumatic hydraulic pressure controller whenever the maximum safe operating speed is encountered.

225-7.3.3.2 Low Pump Suction Pressure. Oil that is used for control purposes passes through the low pump suction pressure safety trip. Whenever the feed pump suction pressure drops to some predetermined minimum below which failure of the pump might ensue, actuation of the low pump suction pressure safety trip occurs and as a result, the pressure in pilot and power oil circuits drops to zero. It will be observed that loss of pressure in either the pilot or power oil circuits causes closure of the governor valve which effects shutdown of the turbine. The low pump suction pressure safety trip is a component of the standardized turbine.

225-7.3.3.2.1 Power Oil. Power oil is supplied from the outlet of the low pump suction pressure safety trip and passes through a fixed area orifice. The oil pressure on the servo motor piston is made variable by means of a variable area orifice (servo motor pilot valve). Power oil to the governor valve servo motor provides sufficient force to overcome the force of the large spring which, in the absence of power oil pressure, effects closure of this governor valve.

225-7.3.3.2.2 Pilot Oil. Pilot oil is supplied from the outlet of the low pump suction pressure safety trip and passes through a fixed area orifice. Control of the servo motor pilot valve position (therefore, control of governor valve also) is obtained by controlling the pressure in the pilot oil line. By varying the force of the spring on the cup valves within the speed limiting governor or pneumatic hydraulic pressure controller, the servo motor pilot valve (and the governor valve by way of servo motor) responds to either the speed limiting governor or the pneumatic hydraulic pressure controller.

225-7.3.3.3 Pneumatic Hydraulic Pressure Controller. Pneumatic hydraulic pressure controller converts the pneumatic signal to a hydraulic signal. The relationship between air signal pressure and pilot oil pressure is linear, and the same for all ships either 1,200 psig boilers or 600 psig boilers.

225-7.4 HIGH-PRESSURE PIPING

225-7.4.1 GENERAL NOTES. All welding shall be according to Class P-1 piping of MIL-STD-278 (Welding and Casting Standard). Weld joint design shall comply with MIL-STD-22 (Welded Joint Design), P-3 for butt weld, P-14 for socket weld, and P-72 for welded branch connections. Nondestructive tests for these joints shall comply with MIL-STD-271, (Requirements for Nondestructive Testing Methods). Acceptance standards for radiograph and magnetic particle (or liquid penetrant) inspection shall comply with Naval Sea Systems Command (NAVSEA) 0900-LP-003-9000 (Radiographic Standards for Production and Repair Welds) for radiograph and NAVSEA 0900-LP-003-8000 (Metals Surface Inspection Acceptance Standards) CL-1 for magnetic particle and liquid penetrant. Preheat and postheat requirements shall comply with requirements of MIL-STD-278 (see Figure 225-7-3).

a. Root connections, up to and including body of root valves, shall be insulated as shown according to MIL-STD-769, Thermal Insulation Requirements for Machinery and Piping. All valves, piping, and fittings between root valves and transmitters shall be uninsulated, except as shown in figure 5 of NAVSEA dwg 4182. Root valves for drum level transmitter, top connection only, and both steam flow transmitter root valves shall be installed with stem in horizontal position.

b. Piping shall be adequately supported throughout its length. Hangers and supports shall not be separated by more than 3 feet, where possible.

c. All reservoirs shall be mounted horizontally.

d. For steam flow systems, both root valves and both reservoirs shall be on the same level.

e. For feedwater flow systems, root valves shall be mounted lengthwise and level with each other.

f. Piping shall be supported from equipment so that no strain is imposed on the root connection.

g. Root connection for MFP header transmitter shall come off side of headers.

h. For superheater outlet or common header steam pressure connection, root connection shall be located on top centerline of pipe in a section with a stable flow pattern (that is 5 feet downstream of tee or major fitting).

i. Root valve design, material, and rating shall be as specified in MIL-STD-777, Schedule of Piping, Valves, Fittings, and Associated Piping Components for Naval Surface Ships.

j. If possible, transmitters for steam and water service should be located below root connections and combustion airflow transmitter above root connections. Drum level transmitter shall always be located below root connections.

k. For steam and water service, transmitter connectors shall be stainless steel Parker Hannifin Ferulok straight thread bite type fitting with metal o-ring seals. For air service, connectors shall be Parker Hannifin Triple-Lok 37 degree flared type, brass, sized to suit.

l. Transmitters shall be located so that they are accessible for maintenance, not attached to the boiler, and not subject to excessive heat or vibration. Stiffeners shall be used as required.

m. Barton transmitters shall be mounted so that the bellows axis of the attached differential pressure unit is parallel (or as close as possible to parallel) to the keel of the ship. Mounting shall not inhibit access to damper adjustment (rear unit).

n. Barton transmitters shall be installed on mounting bracket. Alternate arrangement, with transmitter cradled in bracket, shall be used only when necessary. Bracket shall be bolted, not welded to supporting surface.

o. Barton drum level transmitters are provided with a reverse acting Model 199 differential pressure unit. The output signal from the transmitter should increase for a decrease in differential pressure. The low pressure (LP) port (left side of differential pressure (DP) unit) should be the variable leg, connected to the lower root connection, and the high pressure (HP) port (right side of DP unit) should be the reference leg, connected to the upper root connection.

p. Piping shall have a continuous slope from root connection to transmitter in direction indicated. Minimum slope shall be 1 inch per foot.

q. Tee shall be used for venting and in-place calibration. However, where transmitters contain integral calibration/vent ports, tee may be deleted.

r. Double valves shall be installed for blowdown of sensing piping.

s. A funnel shall be installed below each blowdown valve with sufficient separation to permit observation of fluid during blowdown. Funnel shall be installed in a position that is not hazardous to shipboard personnel.

t. Airflow transmitter furnace root connection size shall be 1-1/2 inch International Pipe Standard (UPS) to facilitate cleanout of piping.

u. Where airflow transmitters are located below (or less than 18 inches above) root connections, sensing piping shall include a vertical run (18 inches minimum length) downstream of root connections to prevent condensation or other foreign matter from plugging transmitter ports.

v. Neither draft gauges nor any other instruments shall be teed into airflow transmitter pressure sensing piping.

MISCELLANEOUS

5–1 PIPING SHALL HAVE A CONTINUOUS SLOPE FROM ROOT CONNECTION TO TRANSMITTER IN DIRECTION INDICATED IN FIGURES. MINIMUM SLOPE SHALL BE 1 INCH PER FOOT.

5–2 TEE SHALL BE USED FOR VENTING AND IN-PLACE CALIBRATION. HOWEVER, WHERE TRANSMITTERS CONTAIN INTEGRAL CALIBRATION VENT PORTS, TEE MAY BE DELETED.

5–3 DOUBLE VALVES SHALL BE USED FOR BLOWDOWN OF SENSING PIPING.

5–4 A FUNNEL SHALL BE INSTALLED BELOW EACH BLOWDOWN VALVE WITH SUFFICIENT SEPARATION TO PERMIT OBSERVATION OF FLUID DURING BLOWDOWN. FUNNEL SHALL BE INSTALLED IN A POSITION THAT IS NOT HAZARDOUS TO SHIPBOARD PERSONNEL.

5–5 AIRFLOW TRANSMITTER FURNACE ROOT CONNECTION SIZE SHALL BE 1–1/2 INCH IPS TO FACILITATE CLEANOUT OF PIPING.

5–6. HYDROSTATIC TESTING-SENSING PIPING, INCLUDING TRANSMITTERS, SHALL BE HYDROSTATICALLY TESTED TO 135 PERCENT OF DESIGN OPERATING PRESSURE ACCORDING TO GENERAL SPECIFICATIONS FOR SHIPS, SECTION 505. THERE SHALL BE NO EVIDENCE OF LEAKS. ALL MANIFOLD VALVES, INCLUDING EQUALIZER VALVES, SHALL BE FULLY OPEN DURING THE TEST.

5–7 VALVE MANIFOLD, PC NO. 9, TO BE INSTALLED WITH EQUALIZER VALVE DOWNSTREAM OF SHUTOFF VALVES.

5–8 WHERE AIRFLOW TRANSMITTERS ARE LOCATED BELOW (OR LESS THAN 18 INCHES ABOVE) ROOT CONNECTIONS, SENSING PIPING SHALL INCLUDE A VERTICAL RUN (18 INCHES MINIMUM LENGTH) DOWNSTREAM OF ROOT CONNECTIONS TO PREVENT CONDENSATION OR OTHER FOREIGN MATTER FROM PLUGGING TRANSMITTER PORTS.

5–9 SUGGESTED ALTERNATE SOURCE FOR PC NO'S 26 AND 27 IS GENERAL REGULATOR CAPILLARY ASSEMBLY (G.R. DWG. NO. A–83872–01).

5–10 RECOMMENDED PIPING ARRANGEMENT FOR MAIN FEED PUMP HEADER TRANSMITTER IS AS SHOWN IN FIGURE 7. HOWEVER, EXISTING INSTALLATIONS, WITH SEDIMENT CHAMBERS INSTALLED AS SHOWN IN FIGURE 3, ARE ACCEPTABLE.

5–11 NEITHER DRAFT GAUGES NOR ANY OTHER INSTRUMENTS SHALL BE TEED INTO AIRFLOW TRANSMITTER PRESSURE SENSING PIPING.

J 5–12 THE NORMAL STANDARD FOR PC NO. 1 SHALL BE NAVSEA DRAWING NUMBER 5534328. HOWEVER, ACCEPTABLE SUBSTITUTES ARE AS FOLLOWS:

(1) LONG BEACH NAVAL SHIPYARD SKETCH NUMBER 260–21–032379.

(2) BAILEY METER CO. MODEL NUMBER 49901K4.

(3) HAGAN CONTROLS CORP DRAWING NUMBER 577684.

L 5–13 AIRFLOW TRANSMITTER SHOULD BE LOCATED AS CLOSE AS POSSIBLE TO TAP TO LIMIT LENGTH OF 1/2" IPS SENSING LINE PIPING TO 30 FEET OR LESS. IF IT IS NOT POSSIBLE TO MEET THIS LENGTH LIMITATION, CONTACT NAVSSES FOR APPROPRIATE PIPING SIZE.

Figure 225-7-3 Automatic Boiler Control Transmitter Pressure Sensing Piping (Sheet 1 of 14)

INSTALLATION AND INSPECTION OF PARKER HANNIFIN FERULOK FLARELESS FITTINGS WITH METAL SEALS

I. THE 7/15" – 20 X 3/8" O.D. TUBE MALE CONNECTOR, PC NO. 4 (PARKER HANNIFIN NO. 6–????U–55) IS USED TO CONNECT THE 3/8" TUBING TO THE LOWER CONNECTION BOSS OF THE BARTON DIFFERENTIAL PRESSURE UNIT (DPC). THE 7/16" – 20 PLUG AND SEAL, PC NO. 16 (4PN–SS) IS USED IN THE UPPER CONNECTION BOSS OF THE DPU. THE 9/15" – 18 X 3/8" O.D. TUBE MALE CONNECTOR, PC NO. 19 (6F9BU–SS) IS USED FOR TUBING CONNECTIONS TO THE EQUALIZER VALVE MANIFOLD. WHEN USED, THE 3/8" O.D. TUBE TEE, PC NO. 7, IS 6JBU–SS AND THE 3/8" O.D. TUBE CAP, PC NO. 8, IS 6FMU–SS.

II. CORRECT INSTALLATION OF THESE FITTINGS IS AS FOLLOWS:

A. SCREW MALE TUBE CONNECTORS AND PLUGS INTO BOSSES. TIGHTEN (FITTING BODY ONLY ON MALE TUBE CONNECTORS) WITH SLIGHT WRENCHING FORCE UNTIL METAL SEAL CONTACTS BOTH THE BOSS SEAT AND THE UNDERSIDE OF THE FITTING BODY WRENCH FLATS. A SHARP INCREASE IN WRENCHING FORCE WILL BE FELT AT THIS POINT. FROM THIS POINT, TIGHTEN THE PLUG OR MALE CONNECTOR FITTING BODY AN ADDITIONAL 1/2 TURN. CAPS ARE TIGHTENED TO 1 TO 1–1/4 TURNS PAST FINGER TIGHT.

B. CUT TUBING TO DESIRED LENGTH WITH A TUBING CUTTER TO ENSURE A GOOD SQUARE CUT AND BEND TUBING AS REQUIRED. USE TUBE CUTTER BURRING BLADE OR SMALL ROUND FILE TO REMOVE INTERNAL BURR ON TUBING. REMOVE ALL DIRT AND FILINGS FROM TUBING.

C. INSERT TUBING INTO FITTING. UNSCREW NUT AND SLIDE BACK ONTO TUBING AND CHECK THAT THE FERRULE'S SMALLER DIAMETER FRONT SECTION IS TOWARD THE FITTING BODY. THE TAIL OR BACK OF THE FERRULE IS THE LARGER DIAMETER SECTION THAT IS KNURLED (KNURLED CONFIGURATION MAY BE USED TO VERIFY THAT FERRULE MATERIAL IS STAINLESS STEEL). HOLD TUBING FIRMLY INTO THE FITTING BODY AND SCREW THE NUT DOWN UNTIL FINGER TIGHT. TIGHTEN THE NUT WITH A WRENCH 1–1/2 TURNS BEYOND FINGER TIGHT. IT IS RECOMMENDED THAT AFTER ONE TURN, TWO WRENCHES, ONE ON THE NUT AND ONE ON THE FITTING BODY WRENCH FLATS, BE USED FOR THE FINAL 1/2 TURN. THE FITTING HAS NOW BEEN PRESET.

D. REMOVE THE TUBE FOR INSPECTION. THE FOLLOWING CONDITIONS SHOULD EXIST:

1. A RIDGE OF METAL HAS BEEN RAISED AHEAD OF THE FERRULE'S FRONT CUTTING EDGE TO A HEIGHT OF AT LEAST 50 PERCENT OF THE THICKNESS OF THE FERRULE'S FRONT EDGE COMPLETELY AROUND THE TUBE.
2. THE TAIL OR BACK OF THE FERRULE SHOULD BE SNUG AGAINST THE TUBE.
3. THE SECTION OF TUBING EXTENDING PAST THE FERRULE'S FRONT EDGE SHOULD APPEAR TO BE SLIGHTLY BELL SHAPED, INDICATING THE FERRULE HAS COMPRESSED THE TUBING AT THE BITE.
4. THERE SHOULD BE A SLIGHT RAISED RIDGE AROUND THE INSIDE OF THE TUBING ADJACENT TO THE OUTSIDE BITE OF THE FERRULE, INDICATING A PROPER BITE HAS BEEN MADE.
5. THE TUBING END SHOULD BE INDENTED SLIGHTLY, INDICATING THE TUBING WAS BOTTOMED IN THE FITTING BODY.
6. THE FERRULE MAY BE ROTATED BUT SHOULD NOT SLIDE BACK AND FORTH ALONG THE TUBE, AND WHEN THE FERRULE IS ROTATED 1/2 TURN THERE SHOULD NOT BE AN UNEVEN GAP BETWEEN THE FERRULE AND BITE.

III. IF THE FITTING DOES NOT MEET THE INSPECTION CONDITIONS SPECIFIED ABOVE, ATTEMPT TO PRESET THE FERRULE AGAIN. REASSEMBLE THE FITTING AND TIGHTEN THE NUT UNTIL A SHARP INCREASE IN WRENCHING FORCE IS FELT. FROM THIS POINT TIGHTEN THE NUT 1/3 TURN (2 FLATS) MORE. DISASSEMBLE AND REINSPECT THE FITTING. IF THE CONDITIONS ARE STILL NOT MET OR AN UNEVEN GAP EXISTS BETWEEN THE FERRULE AND BITE, SCRAP THE TUBING AND START AGAIN WITH A NEW FERRULE AND TUBING.

IV. IF THE INSPECTION CONDITIONS ARE MET, REASSEMBLE THE FITTING AND TIGHTEN THE NUT UNTIL A SHARP INCREASE IN WRENCHING FORCE IS FELT. TIGHTEN THE NUT AN ADDITIONAL 1/? TURN (1 FLAT) AND THE FITTING WILL BE READY FOR SERVICE.

V. CORRECT FINAL ASSEMBLY OF THESE FITTINGS CAN BE CHECKED BY THE FOLLOWING CONDITIONS:

A. THE NUTS WILL JUST COVER THE THREADS ON BOTH SIZES OF MALE TUBE CONNECTORS.

B. WHEN TUBING CONNECTIONS ARE MADE TO A TEE FITTING APPROXIMATELY 3/16" OF THREADS (3 OR 4 THREADS) WILL REMAIN SHOWING.

C. WHEN CAPS ARE USED ON TEE FITTINGS 1/16" OF THREADS, 1 OR 2 THREADS WILL REMAIN SHOWING.

Figure 225-7-3 Automatic Boiler Control Transmitter Pressure Sensing Piping (Sheet 2 of 14)

LIST OF MATERIAL – QUAN

PC NO.	DESCRIPTION	STEAM FLOW	FEED-WATER FLOW	STEAM PRES-SURE	DRUM LEVEL	MAIN FEED PUMP	AIRFLOW
1	RESERVOIR	2	– –	– –	1	– –	– –
2	CHAMBER, SEDIMENT	2	2	1	2	SEE NOTE 5–11	– –
3							
4	CONNECTOR, MALE	AS REQ'D SEE FIG 1,1A	AS REQ'D SEE FIG 1,1A	SEE NOTE 3–2	AS REQ'D SEE FIG 1,1A	SEE NOTE 3–2	– –
5	VALVE, SHUT-OFF, 1/2" IPS	4	4	3	4	AS REQ'D SEE FIG 7	– –
6	PIPE, 1/2" IPS	AS REQ'D	AS REQ'D	AS REQ'D	AS REQ'D	AS REQ'D	– –
7	TEE, TUBING, UNION	AS REQ'D SEE FIG 1A	AS REQ'D SEE FIG 1A	AS REQ'D SEE FIG 3	AS REQ'D SEE FIG 1A	AS REQ'D SEE FIG 7	– –
8	CAP, TUBING	↓ ↓	↓ ↓	↓ ↓	↓ ↓	↓ ↓	– –
9	MANIFOLD VALVE	1	1	– –	1	– –	AS REQ'D SEE FIG 6
10	CONNECTOR, MALE	6	6	1	6	SEE NOTE 5–11	– –
11	TUBING, 3/8" O.D.	AS REQ'D	AS REQ'D	AS REQ'D	AS REQ'D	AS REQ'D	– –
12	COUPLING, 1/2" IPS	↓ ↓	↓ ↓	↓ ↓	↓ ↓	↓ ↓	– –
13	TEE, PIPE	– –	– –	– –	– –	– –	1
14	PIPE, 1–1/2" IPS	– –	– –	– –	– –	– –	1
15	COUPLING, 1/2" IPS	– –	– –	– –	– –	– –	AS REQ'D
16	PLUG, HEX HEAD	AS REQ'D SEE FIG 1	AS REQ'D SEE FIG 1	AS REQ'D SEE NOTE 3–2	AS REQ'D SEE FIG 1	– –	– –
17	VALVE, GLOBE, 1/2" IPS	– –	– –	– –	– –	– –	AS REQ'D
18	PIPE, 1/2" IPS	– –	– –	– –	– –	– –	AS REQ'D
19	TEE, FEMALE RUN	– –	– –	– –	– –	– –	AS REQ'D SEE FIG 6
20	PLUG, PIPE	– –	– –	– –	– –	– –	2
21	TUBING, 1/8" O.D.	– –	– –	– –	– –	– –	AS REQ'D
22	BUSHING	– –	– –	– –	– –	– –	1
23	BUSHING	– –	– –	– –	– –	– –	1
24	BUSHING	– –	– –	– –	– –	– –	1
25	CAP, PIPE	– –	– –	– –	– –	– –	1
26	TUBING, 1/8" O.D.	– –	– –	– –	– –	– –	AS REQ'D SEE FIG 6
27	CONNECTOR, MALE	– –	– –	– –	– –	– –	
28	BUSHING	– –	– –	– –	– –	– –	
29	TEE, PIPE	– –	– –	– –	– –	– –	
30	CONNECTOR, MALE	– –	– –	– –	– –	– –	↓ ↓
31	BUSHING	– –	– –	– –	– –	AS REQ'D SEE FIG 7	– –

Figure 225-7-3 Automatic Boiler Control Transmitter Pressure Sensing Piping (Sheet 3 of 14)

TITIES PER TYPICAL FIREROOM

MATERIAL	SUGGESTED SOURCE SEE NOTE 1–5 MFG	MFG. NO.	SPECIFICATION OR STANDARD	REMARKS	PC NO.	
CARBON STEEL	SEE NOTE 5–12		SEE NOTE 5–12	INLET – 1/2" IPS NIPPLE OUTLET – 1/2" IPS SOCKET WELD	1	K J
↓	--	--	NAVSECPHILA 04V DWG 4279	INLET AND BLOWDOWN CONNECTIONS 1/2" IPS SOCKET WELD	2	K
					3	
STAINLESS STEEL	PARKER HANNIFIN	FERULOK 6–4F58U–SS	--	3/8" O.D. TUBING X 7/16–20 ST THD INCLUDES METAL SEAL	4	
CARBON STEEL	--	--	MIL–V–22094	SOCKET WELD CONNECTIONS	5	K
↓	--	--	MIL–T–20157 TYPE E		6	K J
STAINLESS STEEL	PARKER HANNIFIN	FERULOK 628U–SS	--	3/8" O.D. TUBING SIZE	7	
↓	↓	FERULOK 6FNU–SS	--	3/8" O.D. TUBING SIZE	8	
CARBON STEEL	--	--	NSN 9C–4820 00–547–0715	CONNECTIONS MS–16142 FOR 3/8" O.D. TUBING, SEE NOTE 5–7	9	
STAINLESS STEEL	PARKER HANNIFIN	FERULOK 6F98U–SS	--	3/8" O.D. TUBING X 9/16"–18 ST THD INCLUDES METAL SEAL	10	
S.S. TYPE 304	--	--	MIL–T–6506	SEAMLESS ANNEALED, 0.049" WALL	11	
CARBON STEEL	--	--	ANSI–B16–11	SOCKET WELD CONNECTIONS	12	K
BRONZE	--	--	MIL–F–1183 TYPE A	1–1/2" SOCKET BRAZE CONNECTIONS SEE NOTE 5–2	13	
COPPER	--	--	MIL–T–24107	6" LONG ONE END THREADED NPT	14	
BRONZE	--	--	MIL–F–1183	SOCKET BRAZE CONNECTIONS	15	K
STAINLESS STEEL	PARKER HANNIFIN	FERULOK 4PN–22	--	7.16"–20 ST THD, INCLUDES METAL SEAL	16	
BRONZE	--	--	DWG XXX–005722 TYPE I	SOCKET BRAZE CONNECTIONS	17	K
COPPER	--	--	MIL–T–24107	0.065" WALL	18	K
BRASS	PARKER HANNIFIN	TRIPLE-LOCK GM8TX–6	--	CONNECTIONS 3/8" O.D. TUBING AND 1/4" FEMALE NPT	19	
BRONZE	--	--	WWP–471	1/4" NPT SQUARE HEAD	20	
COPPER	--	--	MIL–T–24107	0.049" WALL MIN.	21	
BRONZE	--	--	MIL–F–1183	1–1/2" IPS X 1" OPS SOCKET BRAZE	22	
↓	--	--	↓	1" IPS X 1/2" IPS SOCKET BRAZE	23	
↓	CAJON	8–6–MPW–A–6TSW	--	1/2" IPS X 3/8" O.D. SOCKET BRAZE	24	
↓	--	--	MIL–F–1184	1–1/2" NPT	25	
COPPER	--	--	MIL–T–24107	70" LG X 0.032" WALL. SEE NOTE 5–9	26	
BRASS	PARKER HANNIFIN	TRIPLE-LOCK 2F9TX–8	--	1/6" O.D. TUBING x 1/6" NPT SEE NOTE 5–9	27	
BRONZE	--	--	MIL–F–1184	1/4" NPT X 1.6" NPT	28	
↓	--	--	↓	1/4" NPT	29	
BRASS	PARKER HANNIFIN	TRIPLE-LOCK 6F8TX–8	--	3/8" O.D. TUBING X 1/4" NPT	30	
CARBON STEEL	CAJON	5–8–MPW–A–6TSW	--	1/2" IPS X 3/8" O.D. SOCKET BRAZE	31	

Figure 225-7-3 Automatic Boiler Control Transmitter Pressure Sensing Piping (Sheet 4 of 14)

NOTES

GENERAL

1–1 SCOPE – REQUIREMENTS CONTAINED IN THIS DRAWING ARE INTENDED FOR PRESSURE SENSING LINES TO STEAM GENERATING PLANT AUTOMATIC CONTROL SYSTEM PRESSURE AND DIFFERENTIAL PRESSURE TRANSMITTERS.

1–2 ALL WELDING AND INSPECTION TO BE ACCORDING TO MIL–STD–278. ALL BRAZING AND INSPECTION TO BE ACCORDING TO NAVSEA 0900–LP–001–7000.

1–3 ROOT CONNECTIONS, UP TO AND INCLUDING BODY OF ROOT VALVES, SHALL BE INSULATED AS SHOWS ACCORDING TO MIL–STD–769. ALL VALVES, PIPING, AND FITTINGS BETWEEN ROOT VALVES AND TRANSMITTERS SHALL BE UNINSULATED, EXCEPT AS SHOWN IN FIGURE 5.

1–4 PIPING SHALL BE ADEQUATELY SUPPORTED THROUGHOUT ITS LENGTH. NORMALLY, HANGERS AND SUPPORTS SHALL NOT BE SEPARATED BY MORE THAN 3 FEET.

1–5 MATERIAL MAY BE PROCURED FROM OTHER COMMERCIAL SUPPLIERS PROVIDED IT MEETS THE FUNCTIONAL INTENT OF THIS DRAWING.

ROOT CONNECTIONS

2–1 ROOT CONNECTIONS SHALL BE ACCORDING TO MIL–STD–777, EXCEPT AS SPECIFIED HEREIN. ROOT CONNECTION SIZE SHALL BE 1.2" IPS MINIMUM EXCEPT AS SPECIFIED IN NOTE 5–5.

2–2 ALL RESERVOIRS SHALL BE MOUNTED HORIZONTALLY.

2–3 FOR STEAM FLOW TRANSMITTER INSTALLATIONS, BOTH ROOT VALVES AND BOTH RESERVOIRS SHALL BE ON THE SAME LEVEL. RESERVOIRS SHALL BE MOUNTED SUCH THAT THEIR CENTER LINE IS ON, OR SLIGHTLY ABOVE, THE SAME LEVEL AS THE ROOT CONNECTIONS. HORIZONTAL RUNS OF SENSING LINES BETWEEN RESERVOIR AND ROOT CONNECTIONS SHOULD BE LIMITED TO SHORTEST RUN POSSIBLE. ROOT VALVE STEMS SHALL BE POSITIONED HORIZONTALLY FOR BOTH VERTICAL AND HORIZONTAL PIPING.

2–4 FOR FEEDWATER FLOW SYSTEMS, ROOT VALVES SHALL BE MOUNTED LEVEL LENGTHWISE AND WITH EACH OTHER. SEE FIGURE 4.

2–5 PIPING SHALL BE SUPPORTED FROM EQUIPMENT SO THAT NO STRAIN IS IMPOSED ON THE ROOT CONNECTION.

2–6 ROOT CONNECTION FOR MAIN FEED PUMP HEADER TRANSMITTER SHALL COME OFF SIDE OF HEADER.

2–7 FOR SUPERHEATER OUTLET OR COMMON HEADER STEAM PRESSURE CONNECTION, ROOT CONNECTION SHALL BE LOCATED ON TOP CENTER LINE OF PIPE IN A SECTION WITH A STABLE FLOW PATTERN (THAT IS, 5 FEET DOWNSTREAM OF TEE OR MAJOR FITTING).

2–8 ROOT VALVE FOR DRUM LEVEL TRANSMITTER, TOP CONNECTION ONLY, SHALL BE INSTALLED WITH STEM DIRECTED HORIZONTALLY.

2–9 ROOT VALVE DESIGN, MATERIAL, AND RATING SHALL BE AS SPECIFIED IN MIL–STD–777.

TRANSMITTERS

3–1 IF POSSIBLE, LOCATE TRANSMITTERS FOR STEAM AND WATER SERVICE BELOW ROOT CONNECTIONS AND COMBUSTION AIRFLOW TRANSMITTER ABOVE ROOT CONNECTIONS. DRUM LEVEL TRANSMITTER SHALL ALWAYS BE LOCATED BELOW ROOT CONNECTIONS.

3–2 FOR STEAM AND WATER SERVICE, TRANSMITTER CONNECTORS AND PLUGS SHALL BE FLARELESS TYPE, STAINLESS STEEL, SIZED TO SUIT, WITH METAL SEALS (SUGGESTED TYPE PARKER HANNIFIN FERULOK). FOR AIR SERVICE, CONNECTORS SHALL BE THE FLARED TYPE, BRASS, SIZED TO SUIT (SUGGESTED TYPE PARKER HANNIFIN TRIPLE–LOK).

3–3 TRANSMITTERS SHALL BE LOCATED SO THAT THEY ARE ACCESSIBLE FOR MAINTENANCE, NOT ATTACHED TO THE BOILER, AND NOT SUBJECT TO EXCESSIVE HEAT OR VIBRATION. STIFFENERS SHALL BE USED AS REQUIRED.

Figure 225-7-3 Automatic Boiler Control Transmitter Pressure Sensing Piping (Sheet 5 of 14)

NOTES

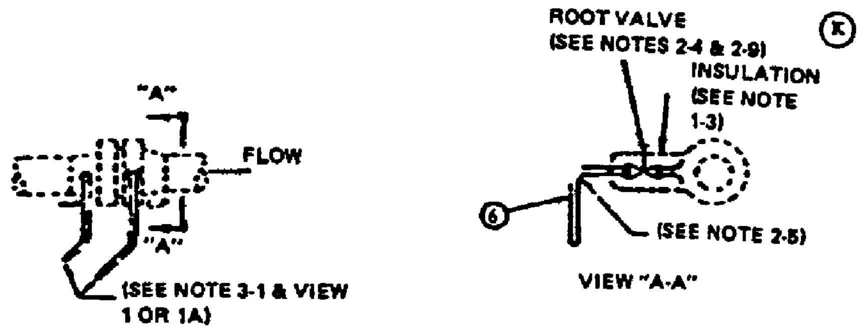
TRANSMITTERS (BARTON)

4–1 SUBJECT TO THE REQUIREMENTS OF NOTE 3–3, BARTON TRANSMITTERS SHALL BE MOUNTED SO THAT THE BELLOWS AXIS OF THE ATTACHED DIFFERENTIAL PRESSURE UNIT IS PARALLEL (OR AS CLOSE AS POSSIBLE TO PARALLEL) TO THE KEEL OF THE SHIP. MOUNTING SHALL NOT INHIBIT ACCESS TO DAMPER ADJUSTMENT (REAR OF UNIT).

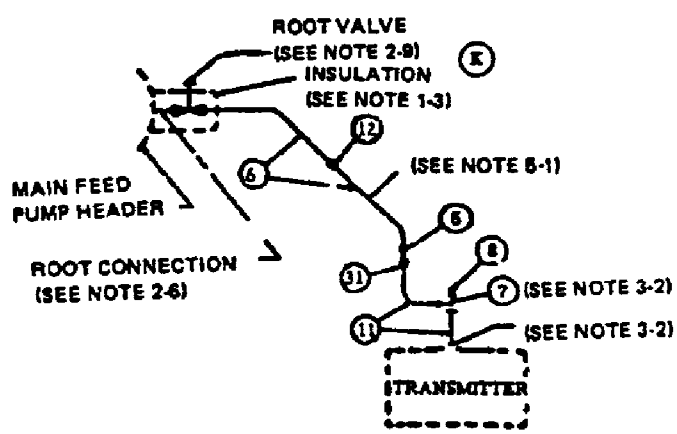
4–2 BARTON TRANSMITTERS SHALL BE INSTALLED ON MOUNTING BRACKET PROVIDED AS SHOWN IN FIGURE 1. ALTERNATE ARRANGEMENT WITH TRANSMITTER CRADLED IN BRACKET, SHALL BE USED ONLY WHEN NECESSARY. BRACKET SHALL BE BOLTED, NOT WELDED, TO SUPPORTING SURFACE.

4–3 BARTON DRUM LEVEL TRANSMITTERS ARE PROVIDED WITH A REVERSE ACTING MODEL 199 DIFFERENTIAL PRESSURE UNIT. THE OUTPUT SIGNAL FROM THE TRANSMITTER SHOULD INCREASE FOR A DECREASE IN DIFFERENTIAL PRESSURE. THE LP PORT (LEFT SIDE OF DP UNIT) SHOULD BE THE VARIABLE LEG, CONNECTED TO THE LOWER ROOT CONNECTION, AND THE HP PORT (RIGHT SIDE OF DP UNIT) SHOULD BE THE REFERENCE LEG, CONNECTED TO THE UPPER ROOT CONNECTION. HP AND LP DESIGNATIONS SHOWN IN FIGURE 1 ARE FOR STEAM FLOW AND FEED WATER FLOW TRANSMITTERS.

Figure 225-7-3 Automatic Boiler Control Transmitter Pressure Sensing Piping (Sheet 6 of 14)

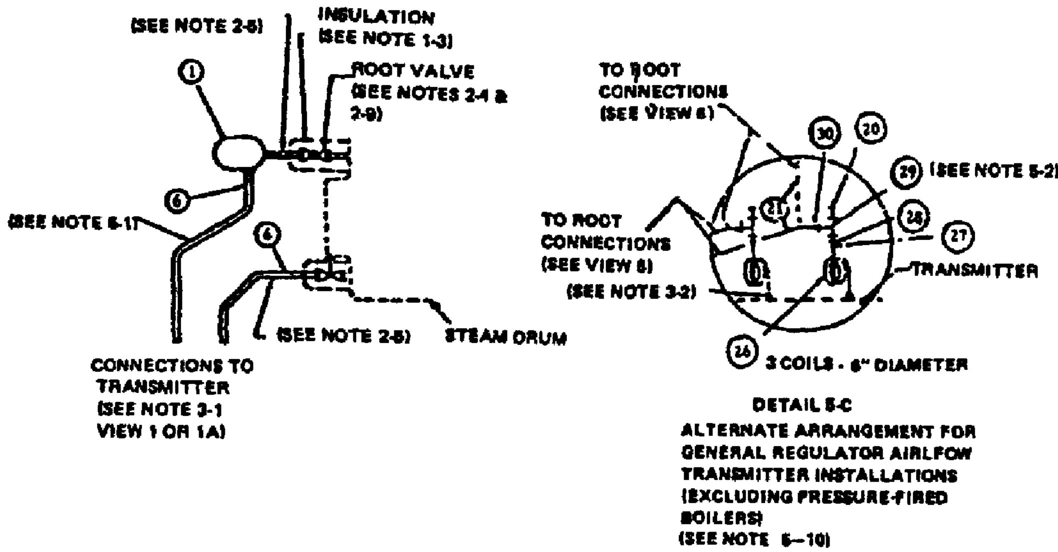


VIEW 4, ROOT CONNECTION - FEED WATERFLOW TRANSMITTER



VIEW 7, PIPING FOR MAIN FEED PUMP HEADER PRESSURE TRANSMITTER (SEE NOTE 5-10)

Figure 225-7-3 Automatic Boiler Control Transmitter Pressure Sensing Piping (Sheet 7 of 14)



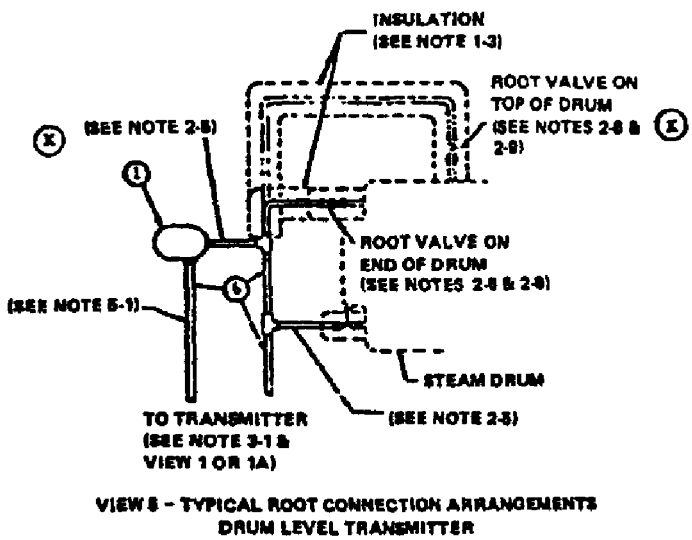


Figure 225-7-3 Automatic Boiler Control Transmitter Pressure Sensing Piping (Sheet 8 of 14)

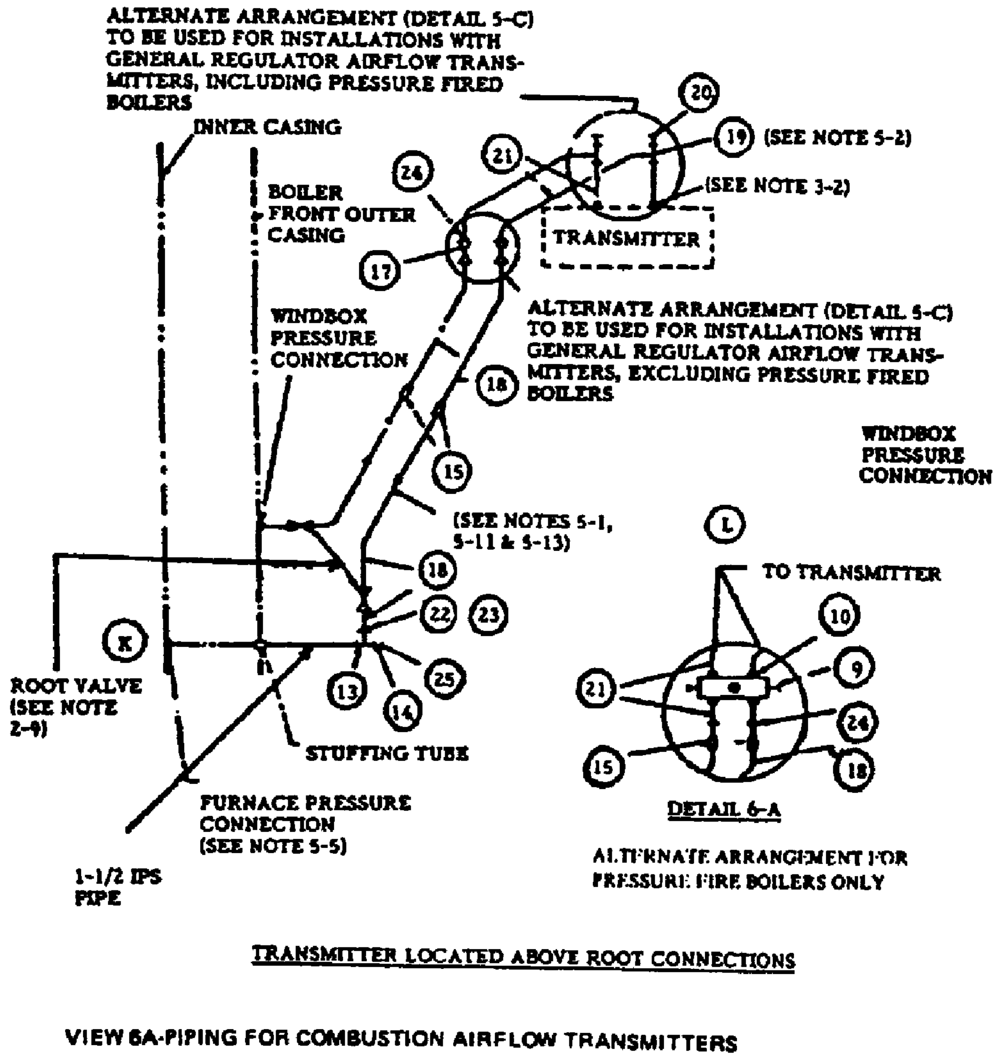
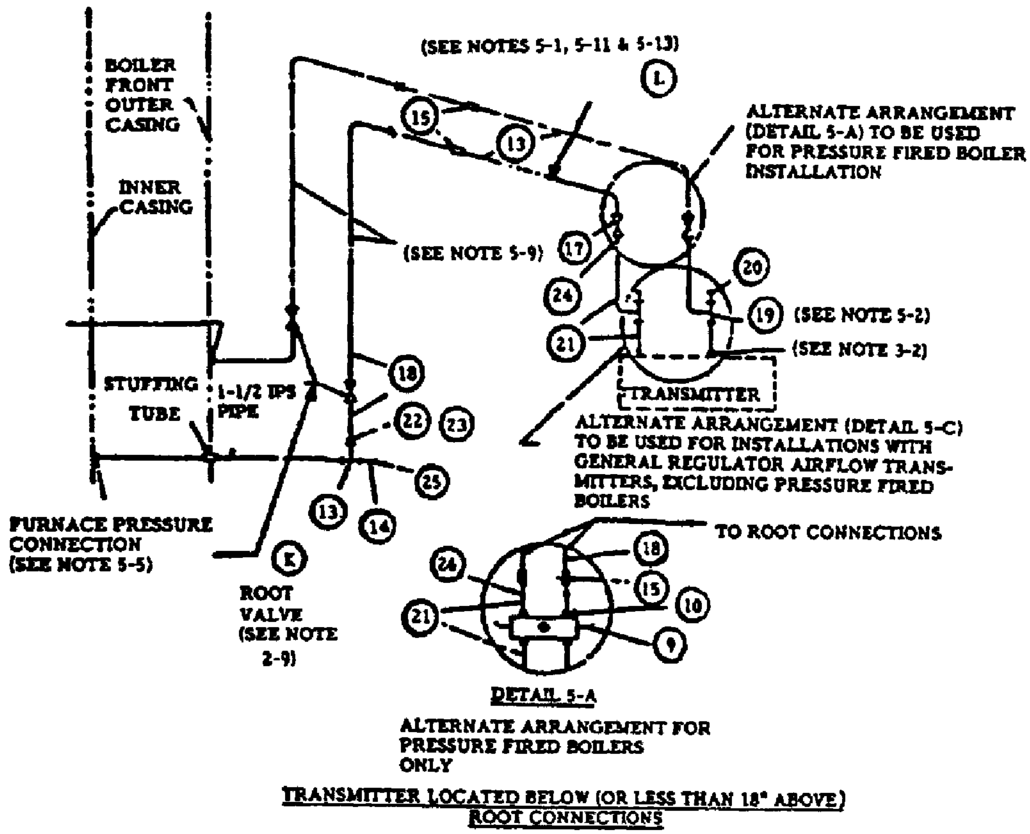


Figure 225-7-3 Automatic Boiler Control Transmitter Pressure Sensing Piping (Sheet 9 of 14)



VIEW 68-PIPING FOR COMBUSTION AIRFLOW TRANSMITTERS

Figure 225-7-3 Automatic Boiler Control Transmitter Pressure Sensing Piping (Sheet 10 of 14)

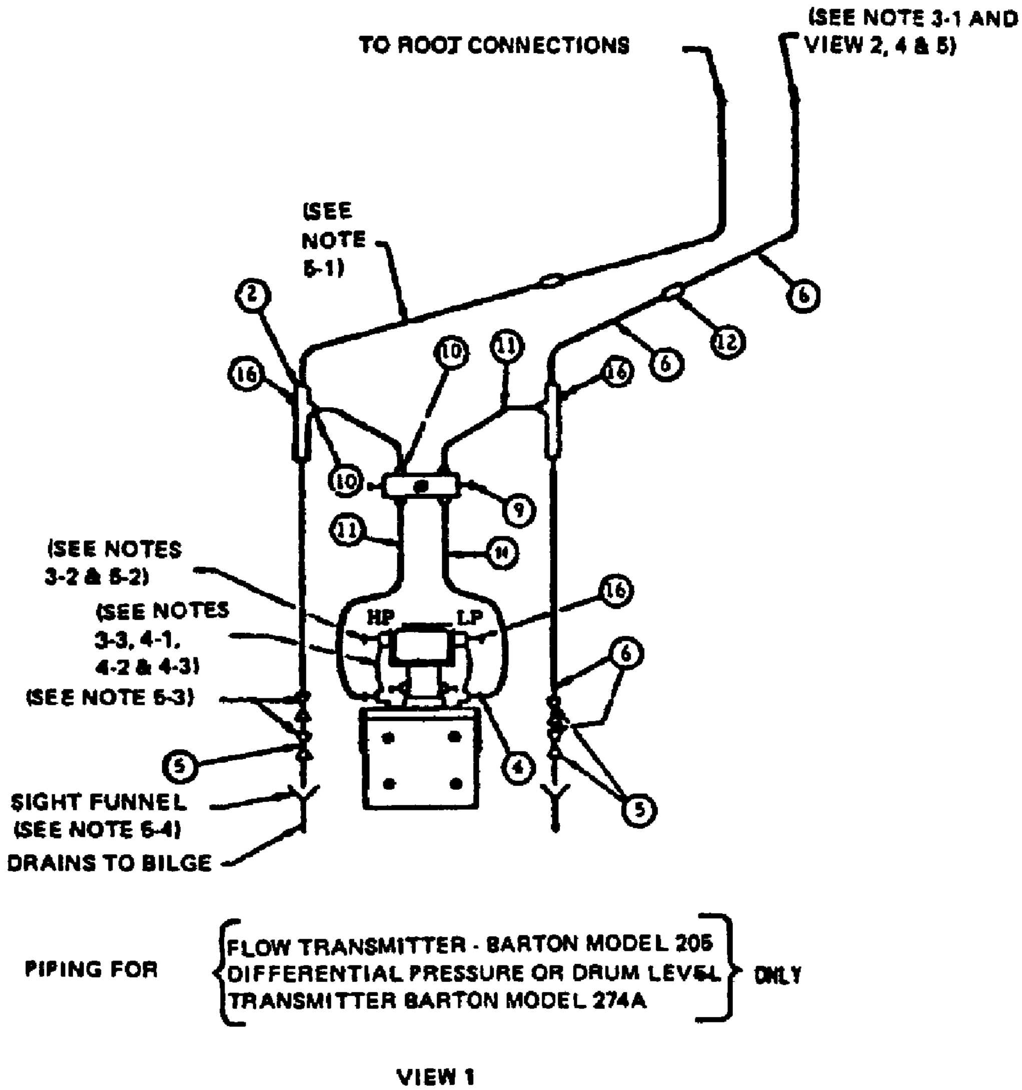


Figure 225-7-3 Automatic Boiler Control Transmitter Pressure Sensing Piping (Sheet 11 of 14)

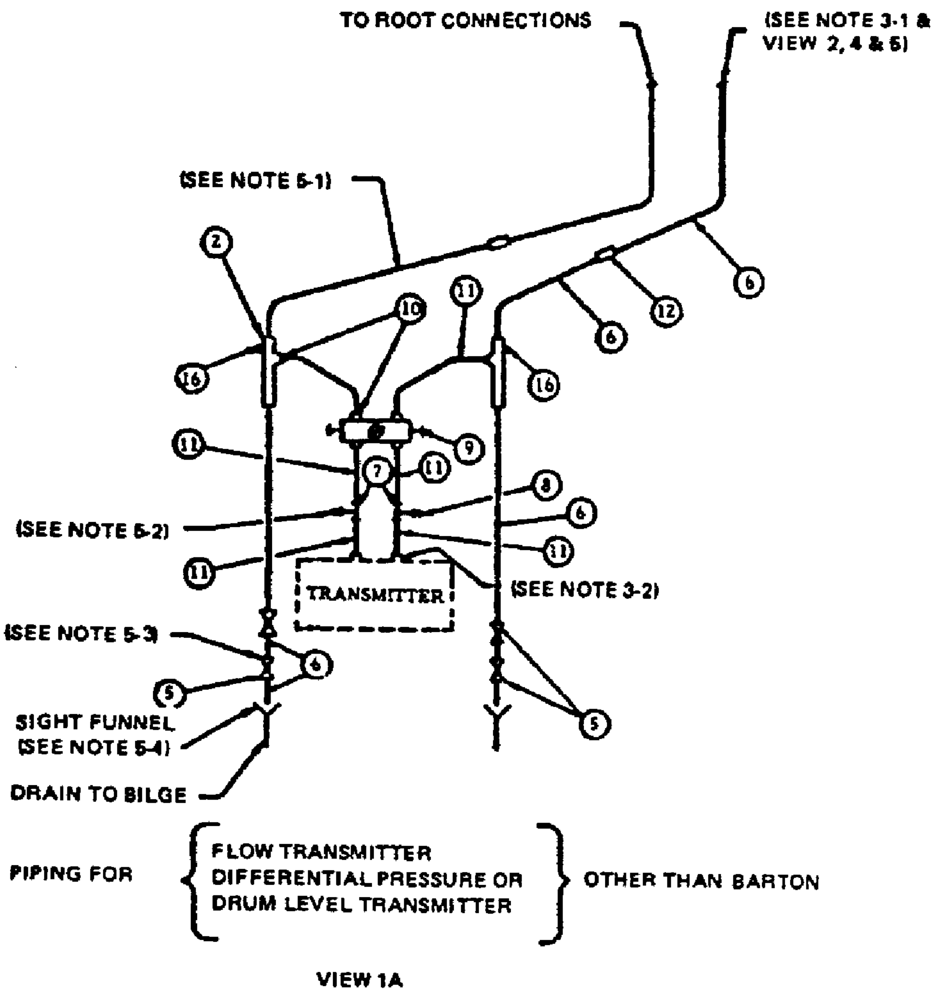


Figure 225-7-3 Automatic Boiler Control Transmitter Pressure Sensing Piping (Sheet 12 of 14)

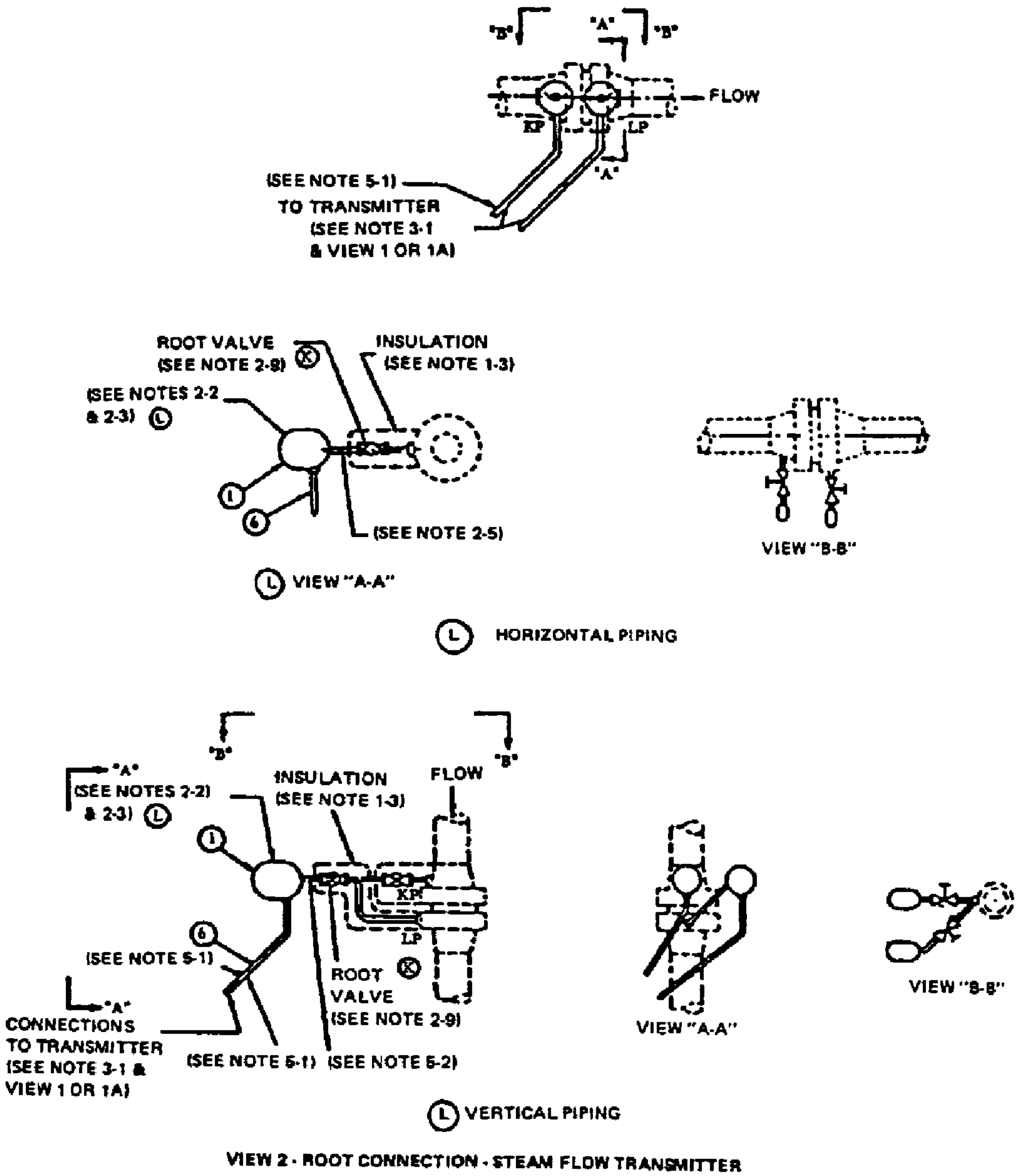


Figure 225-7-3 Automatic Boiler Control Transmitter Pressure Sensing Piping (Sheet 13 of 14)

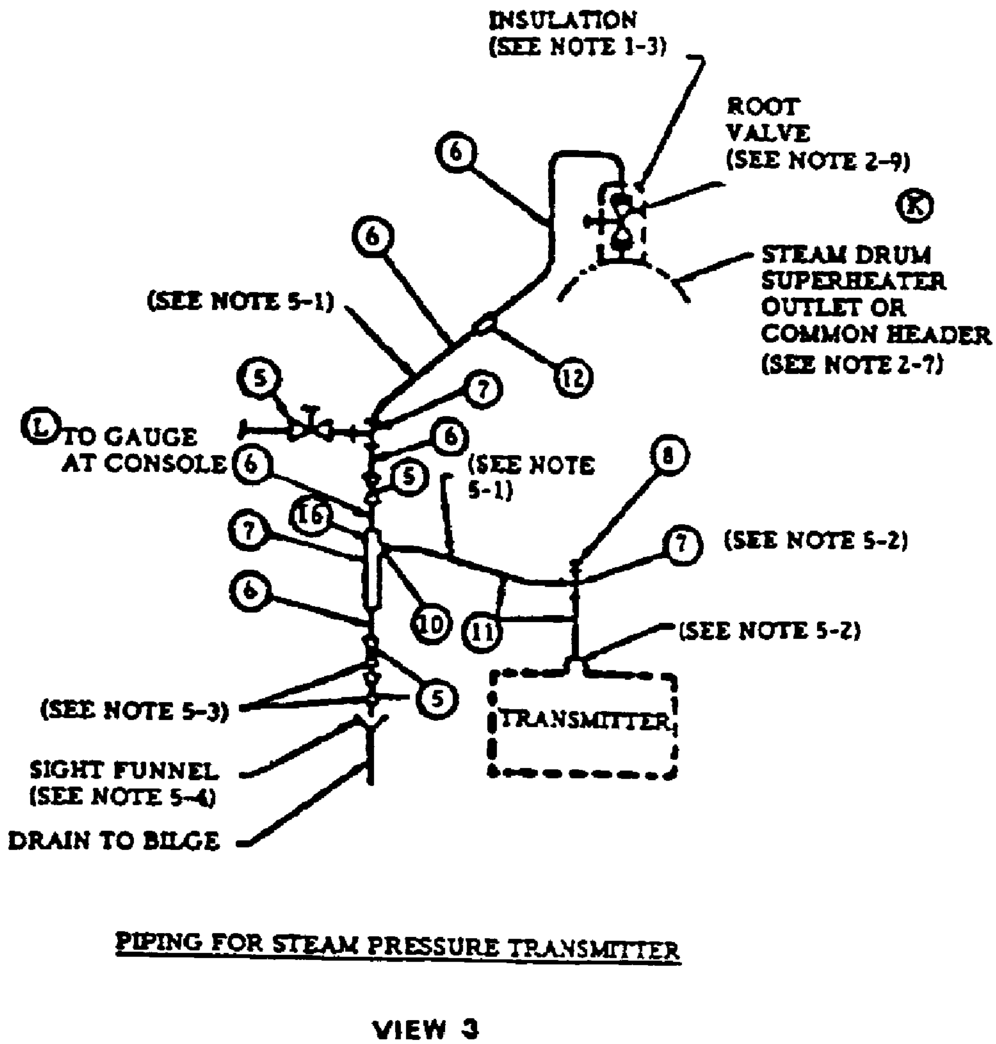


Figure 225-7-3 Automatic Boiler Control Transmitter Pressure Sensing Piping (Sheet 14 of 14)

225-7.4.2 HYDROSTATIC TESTING. Sensing piping, including transmitters, shall be hydrostatically tested to 135 percent of design operating pressure according to General Specifications for Ships, Section 505. There shall be no evidence of leaks. All manifold valves, including equalizer valves, shall be fully open during the test.

225-7.5 PNEUMATIC PIPING

225-7.5.1 GENERAL NOTES. Fabrication and inspection of brazed piping shall comply with NAVSEA 0900-LP-001-7000, Fabrication and Inspection of Brazed Piping Systems.

225-7.5.2 TUBING JOINT AND THREAD CONNECTION DATA. Information concerning tubing joint and thread connection is listed in the following paragraphs.

a. Pneumatic tubing joints shall be tested for tightness at operational pressure (15 psig or 60 psig) with a leak detector (soap solution).

b. Tapered thread connections are authorized for low pressure (125 psig maximum) air service connections to Automatic Boiler Control (ABC) components.

c. Three-piece 37 degree flare brass fittings configured according to MIL-F-18866 shall be used for low pressure tubing connections.

d. Silver brazed fittings shall comply with MIL-F-1183 and flare connections shall be 37 degrees according to MIL-F-18866.

e. Pneumatic system tubing shall be cleaned.

225-7.6 AIR SUPPLY AND AIR LOCK SYSTEMS

225-7.6.1 PURPOSE. The air supply system provides compressed air at the correct pressure for operation of the pneumatic components of the Automatic Combustion Control (ACC), Feedwater Control (FWC), and FPC systems. The purpose of the air lock system is to lock the final control elements of the ACC/FWC/FPC system in the position existing at the time of an air supply failure. This provides a safe means of transition from automatic to local manual control with minimum change in machinery plant operation.

225-7.6.2 AIR SUPPLY SYSTEM. The typical General Regulator air supply system for the ACC and FWC system components, shown in Figure 225-7-4, consists of four line filters, four air pressure regulating valves, and one air supply relief valve for each fireroom. In addition, a separate filter regulator is installed for the FWC valve. The air supply system for the feed pump constant pressure control system components consists of two line filters and two air pressure reducing valves per fireroom. The air supply system for the feed pump recirculation control system components consists of two line filters and two air pressure reducing valves per fireroom. Pressurized air of 100 to 120 psig is supplied by the ship’s vital air system. The filtered air supply for the ACC and FWC system components is reduced to 20 and 65 psig. The 20 psig air supply is for all General Regulator ACC and FWC system components except the characterizing relays and forced-draft blower steam admission valve actuators which, along with Hagan ACC and FWC system components, require a 65 psig air supply, and the feedwater regulating valve positioner which requires a 30 psig air supply. The filtered air supply for the feed pump constant pressure control system components is reduced to either 20 or 60 psig depending on the system. The filtered air supply for the Hagan feed pump recirculation control system components is reduced to 30 and 65 psig. The 65 psig supply is for all recirculation control system components, except the pneumatic transfer valves which require a 30 psig supply.

225-7.6.3 DESCRIPTION. The air supply system (Figure 225-7-4) consists of the five components listed in the following paragraphs. A description is included with each component.

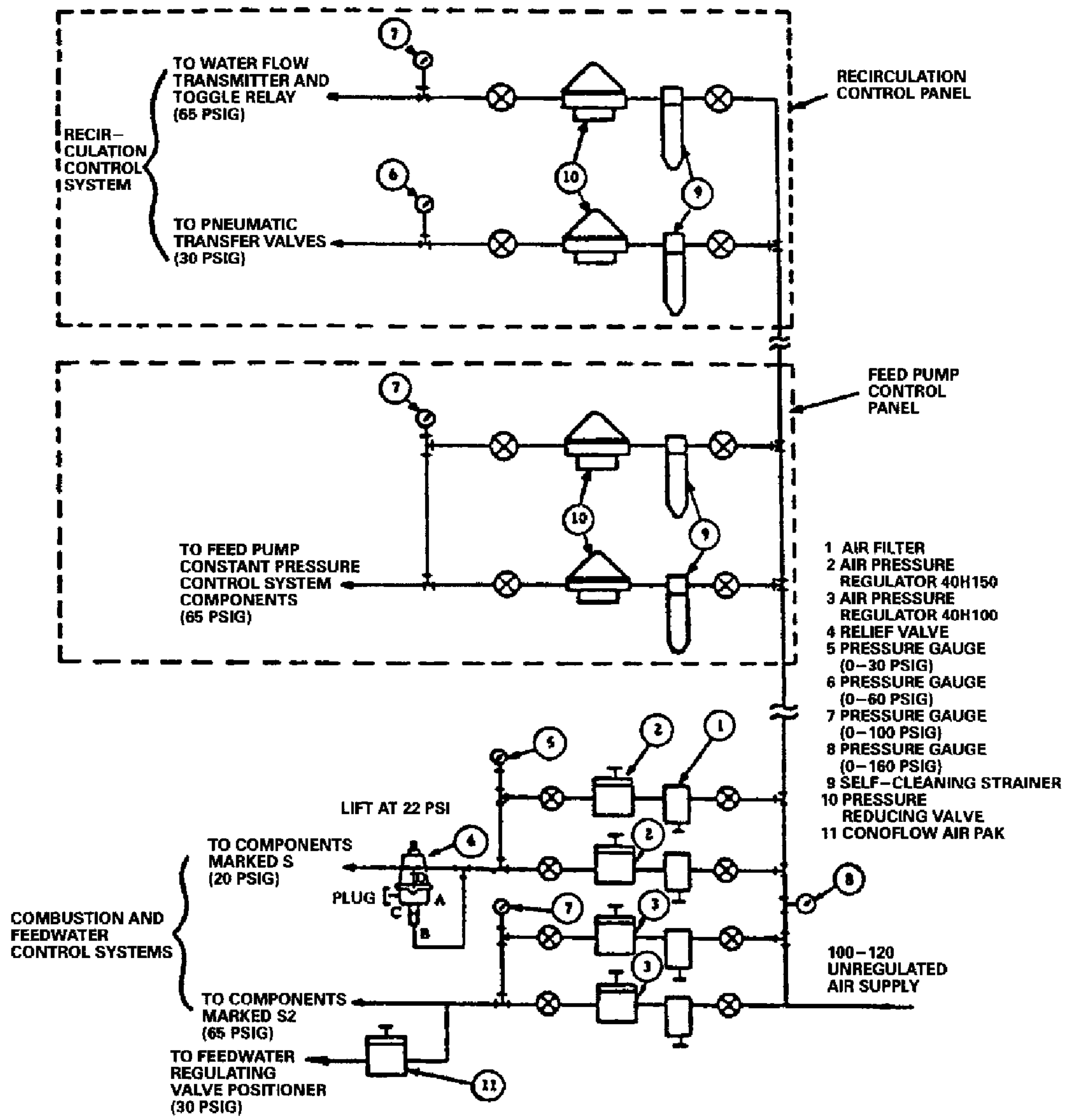


Figure 225-7-4 Typical Air Supply System

225-7.6.3.1 Air Filter. Air filters are used in the supply lines to remove impurities such as oil, fog, moisture, and dirt. The air filters consist of a mounting cap with two 9/16 through 9/18 straight thread connections for input and output, and a housing assembly that encloses a lambs wool filter cartridge. An o-ring is used to seal the connection between the housing and mounting cap, and a petcock is included with the housing assembly for filter blowdown.

225-7.6.3.2 Air Pressure Regulator. Air pressure regulators are used to ensure a constant regulated supply of air pressure to the ACC and FWC systems. The pressure regulators consist of a loading spring housing, center and exhaust rings with interspaced diaphragms, and a bottom housing. Included in the assembly are a pilot valve, exhaust diaphragm assembly regulator loading spring, and spring adjusting mechanism. Three 1/4-inch National Pipe Taper (NPT) connections are provided for input, output, and test gauge connections.

225-7.6.3.3 Air Pressure Relief Valve. An air pressure relief valve is used to ensure that the regulated air supply to control system components does not exceed allowable limits. Excessive supply air pressure will impede component operation and could cause component damage.

225-7.6.3.4 Self-Cleaning Strainer. Self-cleaning strainers are used in the air supply lines to remove impurities such as oil, fog, moisture, and dirt.

225-7.6.3.5 Pressure Reducing Valve. The pressure reducing valves maintain the constant pressure of compressed air required for the operation of the FPC system components. The pressure reducing valve consists of a diaphragm having air pressure on one side, and the loading from an adjustable spring on the other side. A valve located in the valve body, and moved by the diaphragm acting through a plunger, maintains the balance between the air pressures and the spring force. The reducing valve is located directly in the air supply piping with a line type pressure gauge installed at the outlet of the reducing valve and reading air pressure directly in per square inch gauge.

225-7.6.4 AIR LOCK SYSTEM. An air lock system is provided to lock the setting of the fuel oil control valve(s), forced-draft blower steam admission valve actuator(s), feed pump pneumatic hydraulic controller(s), forced-draft blower vane actuator(3), and FWC valve(s), in the position existing at the instant of supply air failure. As a result, the fuel oil flow, combustion airflow, feedwater flow, and feedwater pressure are held constant until the fuel oil control valve(s), forced-draft blower steam admission valve actuator(s), feed pump(s), and FWC valve(s) can be transferred to local manual operation. A typical air lock system is shown in Figure 3-1. After the air lock system has been actuated with the reset valve, the output of the pressure regulating valve enters the master trip valve at connection D to hold it in the open position. Supply air passes through the master trip valve to connection D of the individual air lock valves. The master trip valve will remain in the open position as long as the supply air pressure exceeds the setting of the spring adjusting screw on top of the master trip valve. The air pressure regulator ensures that the air lock valve diaphragms do not fail due to overpressurization.

225-7.6.5 DESCRIPTION. The air lock system (Figure 3-1) consists of the seven components listed in the following paragraphs. A description is included with each component.

225-7.6.5.1 Air Lock Reset Valve (Item 11). The air lock reset valve, mounted on the air lock panel, is a manually operated, spring-loaded OFF-ON switch used for restoring compressed air to the air lock system. The valve stays in the OFF position until the reset button is depressed. In the ON position, the stem opens the passage between the inlet and outlet ports to allow pressure transfer from one line to another. The reset button is kept depressed until a pneumatic signal has been transferred. The compressed air supply is connected to the inlet port of the reset valve. The output is connected to the master trip valve, port D, and through a needle valve to port A of the master trip valve and port D of the individual air lock valves.

225-7.6.5.2 Air Pressure Regulator (Item 12). An air pressure regulator is used to maintain a constant supply air pressure to the master air lock trip valve. The pressure regulator consists of a loading spring housing assembly, pilot and exhaust rings with interspaced diaphragms, and a bottom housing. Included in the assembly are pilot valve, cleaning plunger assembly, exhaust diaphragm assembly, regulator loading spring, and spring adjusting mechanism. Three 1/8-inch connections are provided for input, output, and test gauge connections.

225-7.6.5.3 Master Air Lock Trip Valve (Item 13). The master air lock trip valve is a three-way diaphragm operated (spring-opposed) valve, which is held in the normally open position when air pressure applied to port D is at a pressure greater than setpoint. Port C is vented and air is applied through ports B-A to port D of the final control element air lock valves.

225-7.6.5.4 Final Control Element Air Lock Valves (Item 13). The ACCIFWC/ FPC and element air lock valves are three-way diaphragm operated valves. An adjustable spring opposes the air lock header pressure applied to the diaphragm at port D. The control signal enters port A and passes through the air lock valve to port B. Port C is plugged. These valves are located in the output of the FWC valve positioners, the signal lines to the fuel oil control valves and feed pump hydraulic controllers and the forced-draft blower steam admission valves. As long as the compressed air supply pressure is above the trip point of the master trip valve, the air lock header pressure is applied to the diaphragm at port D of the individual air lock valves, causing port B to open to port A. This allows the signal to the final control element to pass through the valve. When the compressed air supply falls below trip point of the master trip valve, the master trip valve vents and causes the air lock header pressure to rapidly decrease to zero. When the pressure at port D falls below 40 psig, spring action of the individual air lock valves repositions the stem to connect plugged port C to port A, thus trapping the existing control signal and holding the final control elements in the position existing before the supply air failure.

225-7.6.5.5 Air Lock Vent Valve (Item 14). The air lock vent valve is installed between the air lock valve and the final control element to manually vent the final control element control signal after a supply air failure, and allow local manual operation.

225-7.6.5.6 Needle Valve (Item 15). A needle valve is used to aid in resetting the master air lock trip valve. The needle valve consists of a valve body, needle, and o-ring. The input and output connections are 1/4-inch NPT.

225-7.6.5.7 Air Lock Panel, Pressure Switch (Item 16). The pressure switch is used to provide a pneumatic electrical interface for indicating variations from a preset pneumatic value by actuating the alarm. The pressure switch consists primarily of a pneumatic actuator and a switch. Both items are contained within an enclosure. The pneumatic input connection is 1/4-inch NPT and the electrical output connections are screw terminals.

225-7.6.6 AIR LOCK SYSTEM OPERATION. In the event the air supply fails and the pressure falls below the master trip valve spring setting, the master air lock valve will actuate and exhaust the air lock header pressure from the individual air lock valves (D connections) back through connections A-C of the master trip valve, (connection C is vented to the atmosphere). This triggers the individual air lock valves to close, locking the control signal in the fuel oil control valve, forced-draft blower steam admission valve actuator, pneumatic hydraulic controller, and pneumatic operator of the FWC valve. The fuel oil flow, combustion airflow, feedwater flow, and feedwater pressure will be held at the rates existing at the instant of the supply air failure.

225-7.6.7 RESETTING AIR LOCK SYSTEM. After air failure has occurred, the combustion, feedwater, and feed pump controls should be transferred to local manual operation and preparations made to resume normal operation when the air supply is restored. The air lock pressure remain at zero until the air lock system is reset. The air lock system cannot be reset until the unregulated air supply pressure to in excess of the setpoint of the master trip valve. To reset the air lock system, ensure that the air lock vent valve of each final control element is in the VENT position, except for the valves on ships utilizing double-acting forced-draft blower vane actuators which shall be turned to the bypass position. Then the air lock reset valve is depressed and held in position. The available air pressure and the air lock pressures are indicated by pressure gauges on the air lock panel. The reset valve button should be released when air lock pressure exceeds the master trip valve setpoint.

A

Actuating Signal
The difference between the reference input and a signal related to the controlled variable. (Difference between setpoint and process.)

Actuator That component of a final control element that converts energy into a mechanical position change in order to change the operating point of the final control element.

Airlock System
An arrangement of control components that acts to fix all final control elements at their positions at the time of reduction of control air supply pressure below a preset value.

Air Register A device used in a boiler casing to regulate the amount of combustion air that enters the furnace and to mix the air evenly with the entering fuel oil.

Automatic Control System
An arrangement of components interconnected so that the operating point and the desired operating point are continuously monitored and acted upon to reduce the difference between these two parameters to some predetermined value.

Automatic-Manual Control Station
An integral unit of control system components that provides the necessary information and switches to facilitate transfer of a particular control loop or subloop from automatic to manual or from manual to automatic operation, and enables remote manual control of a subsequent control element.

Automatic Operation
Operation of an automatic control system and the process under control without human assistance.

Axial In a direction parallel to the axis.

B

Backlash Relative movement at the point of connection between mechanical parts connected together.

Bias Increasing or decreasing a signal by a set amount with the system in automatic operation.

Boiler Full-Power Capacity
The total quantity of steam flow required to develop the specified horsepower of a ship, divided by the number of boilers installed in the ship. Also boiler full-power capacity is expressed as the number of pounds of steam generated per hour at a specified pressure and temperature.

Boiler Load The steam rate of a steam generator at any instant.

Boiler Master A Boiler Master Auto/Manual Station.

Boiler Overload Capacity
As specified in the design of a boiler, usually 120 percent of boiler full-power capacity, either in steaming or firing rate for a particular installation.

C

Calibration

a. The process of adjusting a control system component such that its static performance is in accordance to a desired table or graph.

b. The process of adjusting a control system component such that its dynamic performance can be set equal to that for which it is designed.

Characterizer — A control system component that acts to alter a signal in a predetermined manner to match a nonlinear parameter in the process under control. A function generator.

Closed Loop — A signal path that includes a forward path, a feedback path, and an error detector so arranged as to form a closed circuit.

Combustion Air — The amount of air per unit time being delivered to the boiler furnace.

Combustion Efficiency — The ratio of energy in combustion gases to the maximum energy theoretically available.

Console — Control panel that provides an operator with a remote manual means of controlling the system. The console also gives a visual indication of system performance during automatic operation.

Control Air Supply — Clean, dry air at proper pressure for operation of pneumatic control equipment.

Control Point — The pneumatic pressure to the final control element.

Control Pressure — The pneumatic pressure to the final control element.

Control Signal — A loading signal applied to a final control element.

Control Valve — A final control element that acts to change the area of a variable orifice according to a signal provided from the control system.

Controlled Variable — That quantity or condition which is measured and controlled such as:

a. Steam Pressure

b. Water Pressure

c. Airflow.

Controller — A component that senses one or more control variables, and acts to provide an output signal that reduces the difference between the input signals to a predetermined value.

Cycling — Control system instability which causes a continuous variation of the control system variable.

D

Dead Band — The amount by which the input of a device can be changed without affecting the output.

Dead Time — The interval of time between initiating an input change and the starting of response result.

Demand Signal — A signal generated by one component in a control system which requires other components to respond to maintain the system at the desired value. (A variable setpoint).

Deviation — The difference between the instantaneous value of the controlled variable corresponding to desired value. (During load changes).

Diaphragm Motor
An actuator using a pneumatic diaphragm mechanism to supply the energy and force required to position a final control element.

Differential Relay
A computing relay that has two input loading signals and produces an output proportional to their difference.

Drift An undesired change in the output of a device which is independent of either input or load.

Droop The error of a system expressed as a function of a load. See offset.

Error The difference between a setpoint and a feedback signal.

Feedback The returning of a fraction of the output to the input.

a. Pneumatic (Controller Feedback)

b. Mechanical (Positioning Valves).

Filter A device through which pneumatic air supply is passed to remove dirt, dust, and other impurities.

Final Control Element
That portion of the controlling means which directly changes the value of the manipulated variable.

a. Valves

b. Actuators

Flow Transmitter
A transmitter that produces an output signal proportional to flow.

Force-Balance
An arrangement of control system components using a mechanical force as the feedback signal. The feedback applied force shall null the forces acting on a balanced mechanism.

Fuel-Air Ratio Relay
A component that is used to manually adjust the amount of combustion air to provide for optimum combustion.
G

Gain The ratio of the signal change that occurs at the output of a device to the change at the input.

Hunting That action of an automatic control system and controlled process that is characterized by continuous cycling of a process or control system variable.

Linear A linear relationship exists between two quantities when a change in one quantity is proportional to the change in the other quantity.

Load Steam production demanded of a boiler by the operation of steam driven equipment.

Loading Pressure
The pneumatic signal between two items of a pneumatic control system except to the final control element. (Loading signal.)

Loading Signal
An input air signal to a control system element.

Loading Spring (Controller)
A spring positioned so that its change in length provides a force acting in a similar manner to the input signals to the controller.

Loading Spring (Transmitter or Valve)
A spring positioned within a transmitter or valve such that its tension determines the zero setting of the transmitter or valve. Determines range of valve or transmitter.

Local-Manual Operation
Direct manual positioning of a control valve or power operator by means of a handwheel or lever.

M

Manipulated Variable
The quantity or condition which is varied by the automatic control system to effect the value of the controlled variable.

a. Airflow

b. Fuel flow

c. Steam flow

d. Feed flow.

Master Demand Signal
Signal that represents a demand for airflow and fuel flow to the boiler.

N

Needle Valve
A variable orifice which acts as a flow restriction to decrease turbulent flow and system response time.

O

Offset
The steady state difference between the value of the controlled variable and the value of the controlled variable corresponding to desired value.

Open Loop System
A system in which the output is allowed to vary according to the characteristics of the system and of the input signal without reference to the system output.

Orifice
A circular opening in a flow passage which acts as a flow restriction.

P

Pneumatic
Driven or operated by air pressure.

Positioner
That part of a control drive that is loaded by a control signal and supplies energy to an actuator in such a manner as to position the final control element according to the control signal.

Pressure Transmitter
A transmitter that produces a signal variation proportional to a change in the pressure which it senses.

Primary Element
: That portion of the measuring means which first utilizes or transforms energy from the controlled medium to produce an effect which is a function of change in the value of the controlled variable.

a. Orifice

b. Nozzle

Proportional Action
: The action of a controller in which the output loading pressure adjusts proportionally with a change in the measured variable.

Proportional Band
: The amount the input shall change to cause the output to change from minimum to maximum. (Gain.)

a. $\text{P.B.} = \dfrac{100}{\text{Gain}}$

b. $\text{Gain} = \dfrac{100}{\text{P.B.}}$

1.

NOTE

Proportional band is most useful when comparing the change in a controlled variable to the change in the output of a transmitter. For example, the change of steam pressure of 300 to 900 psig causing the output of the transmitter to change from 3 to 15 psig.

NOTE

Gain is most useful when comparing changes in loading pressures.

Proportional Controller
: A controller whose output signal varies in proportion to its input signal.

Proportional Offset
: A steady-state error having a linear relationship to load and resulting from closed loop proportional control.

Proportional-Plus-Reset-Controller
: A controller whose output varies in proportion to the difference between two signals and to the difference multiplied by the length of time it exists.

R

Rate Action
: The action of a controller in which the magnitude of change in the output signal is proportional to the rate of speed of input changes.

Relay Sender
: A control system component which provides a means for manually setting a signal.

Remote-Manual Operation
: Human operation of a process by manual manipulation of loading signals to the final control elements.

Reset Action — Action of a controller which is proportional to the product offset.

Reset Rate — The rate at which the output of a proportional-plus-reset controller with unit gain changes in response to a unity error.

Saturation — The state of operation of a control system component such that additional change in the input of the component will not change the output.

Semiautomatic Control — The regulation of a process in which the setpoint for one process operation is adjusted manually; for instance, at the boiler automatic-manual control station.

Sensing Lines — Piping used to connect the sensing element of a transmitter or controller to the measuring point or points.

Setpoint — A reference force introduced into the system to represent some desired value.

Shrink — The drop of the boiler steam drum water level with a decrease of boiler load (downward maneuver). Shrink results from contraction of the water volume in the boiler produced by a decreased volume of steam in the riser tubes.

Signal Input — A signal applied to a system or element.

Signal Output — A signal delivered by a system or element.

Signal Range Modifier — A component which linearly increases or decreases the output for a given input for the entire range of inputs.

Standard — A term used to indicate the desired value of the controlled variable.

a. Water level is at desired value when at normal.

b. When the steam pressure is at design operating pressure it is at standard or desired value.

Steam Drum Pressure — The actual steam pressure in the boiler steam drum.

Steam Header — Portion of pipe through which steam flows from the boiler to the steam operated equipment.

Steam Pressure Controller — Pneumatic controller that senses steam pressure transmitter output, compares it to a setpoint spring force, and applies proportional-plus-reset action to generate a signal that (in conjunction with the control system) acts to hold steam pressure at setpoint.

Superheater Outlet Pressure — Actual steam pressure measured at the boiler superheater outlet.

Swell — The rinse of the boiler steam drum water level with an increase of boiler load (upward maneuver). Swell results from expansion of the water volume in the boiler produced by an increased volume of steam in the riser tubes.

Three-Element Feedwater Control — An automatic feedwater flow control system which senses steam flow, feedwater flow, and drum water level, and acts to maintain boiler drum water level at a constant setpoint.

Transient — The transition period following the initiation of a disturbance before steady-state conditions are obtained.

Transmitter — A device that produces an output signal proportional to the measured variable.

Unstable — That action of an automatic control system and controller process that is characterized by a continuous cycling of one or more system variables to a degree greater than a specified maximum.

Volume Tank — A tank which increases the volume of control air to decrease turbulent flow and system response time.

Zero Setting — The output of a device when its input is minimum.

REAR SECTION

NOTE

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